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Dr. J. W. L. GLAISHER, M.A., F.R.S., PRESIDENT, in the Chair.

Henry Bridger Adames, 5 West Street, Chichester, Sussex, was balloted for and duly elected a Fellow of the Society.

The following Candidate was proposed for election as a Fellow of the Society, the name of the proposer from personal knowledge being appended :—

George McKenzie Knight, 27 King Henry's Road, South Hampstead, N.W. (proposed by Walter E. Besley).

Seventy-eight presents were announced as having been received since the last meeting, including amongst others :—

G. Bigourdan, Sur la prédiction des occultations des étoiles par la Lune &c. ; G. Bigourdan, Observations des nébuleuses et d'amas stellaires, 2 vols., presented by the author ; A. G. Pingré, Annales célestes du dix-septième siècle, publié par G. Bigourdan, presented by the editor ; Preliminary report of the Dutch expedition to Sumatra for the observation of the total solar eclipse of 1901 May, and report of the Dutch observations, No. 12, presented by the Dutch Eclipse Committee ; Royal Society catalogue of scientific papers, 1800–1883, supplementary volume, presented by the Society ; Solar Physics Observatory, catalogue of 470 of the brighter stars classified according to their chemistry, presented by the Observatory ; W. F. Wislicenus, Astronomischer Jahresbericht, 1901, presented by the author.

Comparison of Groombridge's and Struve's Right Ascensions of close Circumpolar Stars. By W. G. Thackeray.

(*Communicated by the Astronomer Royal.*)

How general was the idea that Groombridge's meridian mark was in error is clear from the positive statements made by Dr. Gould in his papers "On the Mean Places of forty-eight Circumpolar Stars," *Astronomical Journal*, Nos. 121, 122, and 130. On p. 1, No. 121, vol. vi., he remarks: "Since there can be no doubt that Groombridge's meridian mark was in error about $2\frac{1}{2}''$," and again on p. 10, No. 122: "right ascensions which, despite the skill and zeal of Piazzi and Groombridge, were referred to erroneous meridian marks." The basis of these positive assertions were the results of the comparison of Struve's and Argelander's observations with those of Groombridge made by Fedorenko and Struve, and which are

$$\text{Argelander-Groombridge} = +0^s\cdot154 + 0^s\cdot188 \tan\delta$$
(Fedorenko, p. 8).

$$\text{Struve-Groombridge} = +0^s\cdot036 + 0^s\cdot130 \tan\delta$$
(Pos. Med. p. cxxviii).

It was Prof. Safford who first (*Monthly Notices*, xlvii. 2, pp. 37–42) sounded a note of doubt on the subject. Dividing the stars common to Struve's and Groombridge's catalogue in four zones he showed that the resulting differences varying but little with the declination, are subject to rather large casual errors, and concluded that "there is but little doubt that the main cause of the discrepancy is instrumental error," and further remarked that "Groombridge's meridian mark was rather too near—about half-mile off—and a previous investigation of Maskelyne's and Pond's observations has shown me that a polar deviation of $\pm 1''$ is not altogether to be avoided when the instrument is adjusted to the meridian from time to time and left for days to its own motions without allowing for azimuth and level error in the modern fashion."

The results of the new reduction of Groombridge's observations for all observations made up to the end of 1810 engrafted on Prof. Safford's paper in the form of corrections conclusively show how right Prof. Safford was in his deductions, and that there is no evidence to support the contention that Groombridge's mark was out of the meridian.

Columns 3 and 4 give respectively the old catalogue and newly reduced place of Groombridge's observations, column 5 the corrections to the old catalogue place, and column 7 the corrected discordance between Struve and Groombridge.

The deduced results of the discussion compare as follows:—

	Mean $\Delta\alpha \times \cos\delta$.	P.E. of one Star.	P.E. of a Groombridge Star.
	s	s	s
Safford original ...	+0·034	±0·093	±0·084
„ corrected ...	−0·026	±0·063	±0·049

The probable error of a Groombridge star was obtained by Professor Safford on the supposition that a liberal allowance for errors of observations in the case of Struve would be $\pm 0^{s}\cdot04$.

Zone +86° *to* +90°.

Groomb. No.	Polar Dist.	Secs. of Groomb. Old.	Secs. of Groomb. New.	New minus Old.	Safford. $\Delta\alpha$ Struve-Groomb.	Safford. $\Delta\alpha$ corrected.	Safford. $\Delta\alpha \cos\delta$ corrected.
	°	s	s	s	s	s	s
144	2·0	34·75	34·97	+0·22	− 1·82	−2·04	−0·07
235	1·7	37·56	39·10	+1·54	+ 0·40	−1·14	−0·03
642	4·0	6·04	6·04	0·00	− 1·14	−1·14	−0·08
1119	0·9	41·13	31·83	−9·30	−12·05	−2·75	−0·04
1141	2·7	58·61	52·94	−5·67	− 3·73	+1·94	+0·09
1850	3·4	48·47	48·62	+0·15	+ 1·09	+0·94	+0·05
1871	2·5	10·11	7·63	−2·48	− 0·67	+1·81	+0·07
1884	1·3	48·37	42·10	−6·27	− 0·93	+5·34	+0·12
2006	1·4	54·33	58·60	+4·27	+ 3·29	−0·98	−0·02
2065	1·5	55·71	64·64	+8·93	+11·80	+2·87	+0·07
2099	3·4	38·56	41·77	+3·21	+ 3·71	+0·50	+0·03
2210	3·3	22·65	24·07	+1·42	+ 3·88	+2·46	+0·14
2283	2·1	17·78	16·57	−1·21	+ 1·63	+2·84	+0·10
2628	3·4	28·63	29·18	+0·55	+ 0·07	−0·48	−0·03
2667	3·1	44·40	45·81	+1·41	+ 0·45	−0·96	−0·05
3308	1·3	41·23	43·27	+2·04	+ 1·83	−0·21	0·00
3548	3·7	46·98	47·84	+0·86	+ 0·88	+0·02	0·00
4101	3·7	39·78	40·44	+0·66	− 0·35	−1·01	−0·06
Zone +83° *to* +86°.							
67	4·7	0·19	2·60	+2·41	+ 0·79	−1·62	−0·13
177	4·8	49·23	49·98	+0·75	+ 0·20	−0·55	−0·04
595	5·8	30·00	31·77	+1·77	+ 2·49	+0·72	+0·07
750	5·0	20·22	21·31	+1·09	+ 0·47	−0·62	−0·05
766	6·7	28·24	29·26	+1·02	+ 0·44	−0·58	−0·06
944	4·9	18·76	18·69	−0·07	− 0·83	−0·76	−0·06
956	4·8	21·23	24·37	+3·14	+ 2·63	−0·51	−0·04
1359	5·4	50·28	46·47	−3·81	− 5·56	−1·75	−0·16
1418	4·3	22·44	18·94	−3·50	− 5·72	−2·22	−0·17

Zone +83° *to* +86°.

Groomb. No.	Polar Dist.	Secs. of Groomb. Old.	Secs. of Groomb. New.	New minus Old.	Safford. Δα Struve-Groomb.	Safford. Δα corrected.	Safford. Δα cos δ corrected.
	°	s	s	s	s	s	s
1620	4·8	56·49	55·78	−0·71	+ 0·47	+1·18	+0·09
1633	6·5	42·14	41·84	−0·30	− 0·33	−0·03	0·00
1889	5·3	26·87	29·29	+2·42	+ 2·91	+0·49	+0·05
1937	5·6	45·56	46·69	+1·13	+ 1·15	+0·02	0·00
1940	5·6	53·71	54·04	+0·73	+ 1·76	+1·03	+0·10
2007	4·3	0·01	1·01	+1·00	+ 1·12	+0·12	+0·01
2063	6·3	23·09	23·49	+0·40	+ 1·24	+0·84	+0·09
2196	6·7	1·86	2·13	+0·27	+ 1·25	+0·98	+0·12
2213	5·3	14·42	15·73	+1·31	+ 1·98	+0·67	+0·06
2315	6·5	3·38	4·69	+1·31	+ 0·83	−0·48	−0·06
2476	6·6	20·33	21·15	+0·82	+ 0·56	−0·26	−0·03
2548	6·6	51·76	51·84	+0·08	− 2·10	−2·18	−0·24
3501	6·5	10·93	11·54	+0·61	− 0·30	−0·91	−0·10
3820	4·8	41·10	42·65	+1·55	+ 0·33	−1·22	−0·10
3824	4·7	18·00	19·81	+1·81	− 0·47	−2·28	−0·18
3970	6·6	27·78	29·65	+1·87	− 0·45	−2·32	−0·27
4193	4·3	57·57	58·90	+1·33	+ 0·20	−1·13	−0·08

Zone +80° *to* +83°.

424	9·6	47·48	48·35	+0·87	+ 0·94	+0·07	+0·01
426	9·4	24·62	25·40	+0·78	+ 1·28	+0·50	+0·08
506	9·2	17·72	17·53	−0·19	− 0·03	+0·16	+0·03
527	9·4	16·32	16·68	+0·36	+ 0·67	+0·31	+0·05
580	9·3	8·73	9·93	+1·20	+ 0·58	−0·62	−0·10
746	9·8	54·54	54·90	+0·36	− 0·05	−0·41	−0·07
774	7·1	22·37	23·27	+0·90	+ 0·43	−0·47	−0·06
779	9·6	37·00	37·30	+0·30	+ 0·47	+0·17	+0·02
785	9·5	48·19	48·94	+0·75	+ 0·52	−0·23	−0·04
856	9·1	19·05	19·82	+0·77	+ 0·99	+0·22	+0·03
1255	8·4	48·24	48·32	+0·08	− 1·17	−1·25	−0·18
1259	7·3	22·39	23·24	+0·85	+ 0·54	−0·31	−0·04
1278	8·8	30·12	30·45	+0·33	− 0·49	−0·82	−0·13
1339	9·3	17·77	17·49	−0·28	− 0·50	−0·22	−0·03
1355	9·7	4·96	6·19	+1·23	+ 0·56	−0·67	−0·12
1391	7·0	36·57	35·81	−0·76	− 0·85	−0·09	−0·01
1431	7·1	49·82	49·70	−0·12	− 1·81	−1·69	−0·21

Zone +80° *to* +83°.

Groomb. No.	Polar Dist.	Secs. of Groomb. Old.	Secs. of Groomb. New.	New minus Old.	Safford. Δα Struve-Groomb.	Safford. Δα corrected.	Safford. Δ cos δ corrected.
	°	s	s	s	s	s	s
1452	9·3	21·70	22·30	+0·60	− 0·56	−1·16	−0·19
1463	9·3	49·55	49·71	+0·16	− 0·83	−0·99	−0·16
1480	8·5	52·89	54·12	+1·23	− 0·08	−1·31	−0·19
1537	7·9	57·35	56·77	−0·58	− 1·46	−0·88	−0·12
1643	8·6	41·61	40·60	−1·01	− 0·85	+0·16	+0·02
1662	8·6	0·59	0·58	−0·01	− 0·36	−0·35	−0·05
1778	7·9	56·30	57·43	+1·13	+ 1·01	−0·12	−0·02
1782	7·9	55·13	55·33	+0·20	− 0·07	−0·27	−0·04
1845	8·1	3·92	4·58	+0·66	+ 1·86	+1·20	+0·18
1858	7·3	12·62	12·01	−0·61	− 0·13	+0·48	+0·06
1909	8·7	11·13	11·93	+0·80	+ 1·31	+0·51	+0·08
1927	8·4	35·80	36·07	+0·27	+ 1·34	+1·07	+0·16
1977	8·5	53·10	52·90	−0·20	+ 0·15	+0·35	+0·05
2037	8·7	46·07	46·30	+0·23	+ 0·05	−0·18	−0·03
2071	8·3	8·70	8·77	+0·07	+ 0·80	+0·73	+0·11
2275	9·0	41·80	42·65	+0·85	+ 1·93	+1·08	+0·17
2276	9·0	54·46	55·27	+0·81	+ 2·06	+1·25	+0·20
2422	7·7	51·28	52·02	+0·74	+ 0·29	−0·45	−0·06
2456	9·7	8·95	9·13	+0·18	+ 0·23	+0·05	+0·01
3268	9·2	17·30	17·52	+0·22	+ 0·40	+0·18	+0·03
3276	9·2	36 30	37·02	+0·72	+ 0·43	−0·29	−0·05
3277	9·6	55·19	55·65	+0·46	+ 0·33	−0·13	−0·02
3370	8·2	35·07	36·14	+1·07	+ 0·85	−0·22	−0·03
3707	8·4	25·24	25·71	+0·47	+ 0·23	−0·24	−0·04
3709	8·4	31·26	31·95	+0·69	+ 0·79	+0·10	+0·01
3887	9·6	46·32	47·37	+1·05	− 0·10	−1·15	−0·19
3928	7·8	52·99	54·19	+1·20	− 0·30	−1·50	−0·20

Zone +70° *to* +80°.

616	13·0	40·30	41·36	+1·06	+ 0·53	−0·53	−0·11
919	11·0	29·89	30·98	+1·09	+ 0·71	−0·38	−0·07
966	15·1	23·25	24·24	+0·99	+ 0·69	−0·30	−0·08
1217	12·8	9·94	10·97	+1·03	+ 0·63	−0·40	−0·09
1562	10·0	4·31	4·31	0·00	− 0·71	−0·71	−0·12
1650	13·3	33·02	35·18	+2·16	+ 0·98	−1·18	−0·26
1859	11·4	6·87	7·57	+0·70	+ 0·58	−0·12	−0·02

Zone +70° *to* +80°.

Groomb. No.	Polar Dist.	Secs. of Groomb. Old.	Secs. of Groomb. New.	New minus Old.	Safford. Δα Struve-Groomb.	Safford. Δα corrected.	Safford. Δα cos δ corrected.
	°	s	s	s	s	s	s
2094	11·6	47·11	47·06	−0·05	+ 0·10	+0·15	+0·03
2130	13·5	4·45	4·27	−0·18	+ 0·21	+0·39	+0·09
2172	15·1	22·80	23·35	+0·55	+ 0·65	+0·10	+0·02
2228	17·5	20·17	20·43	+0·26	− 0·09	−0·35	−0·10
2236	17·5	6·78	7·53	+0·75	+ 0·55	−0·20	−0·06
2268	12·0	16·82	18·16	+1·34	+ 1·46	+0·12	+0·02
2294	11·6	4·97	6·33	+1·06	+ 1·39	+0·33	+0·07
2334	13·7	23·80	24·15	+0·35	+ 0·28	−0·07	−0·01
2336	14 3	28·15	27·53	−0·62	− 0·69	−0·07	−0·01
2349	13·8	11·45	12·25	+0·80	+ 0·67	−0·13	−0·03
2475	17·8	20·32	20·46	+0·14	0·00	−0·14	−0·04
2477	17·8	22·04	22·10	+0·06	− 0·06	−0·12	−0·04
2546	10·0	17·75	12·82	−4·93	(− 4·92)	+0·01	0·00
2547	10·0	24·21	19·29	−4·92	(− 4·98)	−0·06	−0·01
2726	14·8	25·66	25·99	+0·33	+ 0·08	−0·25	−0·06
2930	16·0	1·14	1·72	+0 58	+ 0·43	−0·15	−0·04
3148	12·9	3·00	3·31	+0·31	+ 0·43	+0·12	+0·03
3373	10·1	48·72	48·10	−0·62	− 1·16	−0·54	−0·09
3419	12·6	3·55	4·17	+0·62	+ 0·16	−0·46	−0·10
3508	14·4	8·39	7·96	−0·43	− 0·75	−0·32	−0·08
3511	10·3	0·18	1·47	+1·29	+ 1·74	+0·45	+0·08
3809	12·2	9·65	8·86	−0·79	− 0·71	+0·08	+0·02
3831	12·1	5·42	4·51	−0·91	− 0·82	+0·09	+0·02
3834	14·7	53·22	...	...	− 0·74	...	...
4122	13·4	38·70	38·61	−0·09	− 0·04	+0·05	+0·01

From an independent comparison of the individual observations of some 35 stars spread over the four zones as shown below the p.e. of a Groombridge observation is $\pm 0^s\cdot053$:—

Zone.	East.	Wt.	No. of Stars.	West.	Wt.	No. of Stars.
° °	s			s		
90–86	±0·031	14	3	±0·047	28	5
86–83	±0·066	23	5	±0·056	12	3
83–80	±0·070	20	5	±0·061	23	5
80–70	±0·055	14	3	±0·062	28	6

The Distribution of the Stars of the Cape Photographic Durchmusterung. By A. M. W. Downing, D.Sc., F.R.S.

The publication of the C.P.D. is of peculiar interest as enabling us, for the first time, to attack the problem of stellar distribution on a sufficiently extended scale by a method which is free from many of the disabilities attaching to the older method of eye observing, although liable to other disabilities which affect the photographic method.

Thus the photographic plate is far more efficient than the eye in registering the stars to the same order of magnitude in the richer portions of the sky as in more sparsely occupied regions. On the other hand, the determination of a homogeneous system of stellar magnitudes by photography is a difficult and delicate operation.

Notwithstanding, therefore, the fact that M. Stratonoff has already published an instructive note on the subject in *Astron. Nachrichten*, No. 3710, I have thought that it would be of interest to astronomers to exhibit the general results of an analysis of the C.P.D. which I have made pending the publication of a further discussion of the registered stellar magnitudes which is expected from the authors, more especially as my work is carried out on somewhat different lines from those adopted by M. Stratonoff. In what follows the magnitudes of the catalogue are adopted throughout.

I have omitted the partial zone $-18°$, so that the stars whose distribution is here discussed all lie between $-19°$ dec. and the South Pole (Equinox 1875·0).

The first, and of course by far the most laborious, part of the work was to count the stars of different magnitudes occurring in each zone. The magnitude-groups adopted were (1) o to 6·2, (2) 6·3 to 6·7, (3) 6·8 to 7·2, (4) 7·3 to 7·7, (5) 7·8 to 8·2, (6) 8·3 to 8·7, (7) 8·8 to 9·2, (8) 9·3 to 9·7, (9) 9·8 to 10·2, and (10) 10·3 and fainter. The numbers in the last group were formed by simply taking the differences between the sums of the first nine groups and the total numbers for each zone. The group is relatively too limited in numbers of stars to be of interest to us in the present connection.

In order to avoid the inconvenience of using large numbers I have exhibited the results of the counts as "density," or number of stars in one square degree.

The first table gives the mean density corresponding to each magnitude-group and the ratio (ρ), corresponding to one stellar magnitude computed from the expression

$$n \log \rho = \log D_{m+n} - \log D_m$$

where D_{m+n} is the density from magnitude o to magnitude $m+n$, and D_m is the similar density to magnitude m.

It may be noted that the total number of square degrees comprised in the survey is 13,911·15, and that the aggregate mean density is 32·66. The total number of stars included in the table is 454,381.

TABLE I.

Range of Mag.	Mean Density.	Ratio.
0 to 6·2	·067	
6·3 „ 6·7	·058	3·48
6·8 „ 7·2	·158	5·13
7·3 „ 7·7	·346	4·94
7·8 „ 8·2	·861	5·61
8·3 „ 8·7	1·744	4·71
8·8 „ 9·2	4·619	5·90
9·3 „ 9·7	8·453	4·31
9·8 „ 10·2	12·254	3·07
10·3 and fainter	4·102	

No further reference will be made to the last magnitude-group.

It will be remembered that the authors claim that the survey is complete to mag. 9·2 only. The series of ratios given above would seem to substantiate this view, as there is a decided decrease after the above-mentioned limit is passed.

The next step in the discussion was to transform the places of the stars comprised in the different magnitude-groups to their galactic coordinates in order to investigate their distribution with reference to the galaxy. For this purpose the portion of the surface of the celestial sphere between −19° dec. and the South Pole was divided into zones of galactic latitude as follows :—

I. Latitudes -90° to -70°
II. Latitudes -70 to -50
III. Latitudes -50 to -30
IV. Latitudes -30 to -10
V. Latitudes -10 to $+10$
VI. Latitudes $+10$ to $+30$
VII. Latitudes $+30$ to $+43\frac{1}{2}$

The assumed position of the South Galactic Pole was R.A. $0^h\ 48^m$, dec. $-27\frac{1}{2}^\circ$.

The mean density in each zone was then found for each magnitude-group from the corresponding numbers of stars in each zone of declination and each hour of R.A.

The results of the transformation are exhibited in the following table, where mag. 6·5 means the magnitude-group 6·3 to 6·7 ;

and similarly for the subsequent numbers given in the magnitude column.

Column VIII. gives the mean densities for the different magnitude-groups, excluding the stars in the equatorial zone of the galaxy, which are used in forming Column V.

TABLE II.

Galactic Latitude.

Magnitude.	I. −90° to −70°.	II. −70° to −50°.	III. −50° to −30°.	IV. −30° to −10°.	V. −10° to +10.	VI. +10° to +30°.	VII. +30° to +43½°.	VIII. Excluding the Galaxy.
To 6·2	·043	·053	·050	·077	·101	·066	·030	·059
6·5	·053	·062	·056	·063	·068	·046	·024	·056
7·0	·135	·125	·140	·176	·180	·149	·145	·153
7·5	·244	·268	·292	·352	·487	·353	·284	·312
8·0	·619	·634	·661	·884	1·346	·887	·679	·743
8·5	·917	1·023	1·219	1·869	3·035	1·727	1·386	1·431
9·0	1·489	2·107	2·981	5·116	9·232	4·343	2·865	3·500
9·5	1·618	2·592	4·249	9·464	19·512	7·995	4·689	5·771
10·0	2·593	3 412	5·058	11·354	29·808	15·503	6 280	7·997
Sums	7·711	10·276	14·706	29·355	63·769	31·069	16·382	
Sums to Mag. 9·2	3·500	4·272	5·399	8·537	14·449	7·571	5·413	
B.D.*	3·14	3·21	3·71	6·07	8·17	5·32		

We recognise here the ring of lucid stars lying nearly in the plane of the galaxy to which Gould and others have drawn attention. It will be remarked that the stars in magnitude-groups 6·5 and 7·0 are much more uniformly distributed than are the brighter stars, and that we must come down to magnitude-group 8·0 before we get as great a relative increase in density between the polar and equatorial zones of the galaxy as we find in the group of lucid stars.

The C.P.D. is not sufficiently extended in galactic longitude in this region to enable us to determine from it with accuracy the deviation (if any) of the ring of bright stars from the plane of the galaxy.

In studying the structure of our universe it is important to note the nearly uniform distribution of the stars of medium brightness.

The falling off in relative density after the magnitude 9·2 is passed, to which attention has been already drawn, as shown in Table I., is apparent throughout the zones of galactic latitude; equally in the polar zone (I.), the equatorial zone (V.), and in the mean densities, excluding the equatorial zone (VIII.). This

* Seeliger's discussion of the Bonn *Durchmusterung* (see Newcomb, *The Stars*, page 249).

must not, however, be taken as evidence of any thinning out of the stars of the fainter magnitudes here considered, but rather of the fact that we have passed the limit of magnitude to which the survey is complete.

The "Sums" show the aggregate densities in the different zones of galactic latitude for the stars down to mag. 10·2.

The "Sums to mag. 9·2" show the same down to the limit of magnitude to which the survey is assumed to be complete. The latter series is fairly comparable with the Bonn *Durchmusterung*, the results of which, as deduced by Seeliger, are given in the table. We recognise the greater relative aggregation of stars in the neighbourhood of the galaxy which appears in the photographic, as compared with the visual, survey, to which Kapteyn has drawn attention. Whether this arises from the greater efficiency of the photographic plate in the more crowded regions, or from the greater actinic activity of stars near the galaxy, appears as yet to be an open question. The C.P.D., however, agrees with the B.D. in assigning an ellipsoidal form to our universe of stars to the magnitude here considered, although pointing to a greater ellipticity of the ellipsoid, by reason of the greater relative extension towards the plane of the galactic equator.

Table III. gives the ratios of increase for one magnitude (as defined above for the corresponding quantities in Table I.) for the stars contained in the equatorial zone of the galaxy (I.), and for the residuum of stars, excluding this zone (II.). The latter series is comparable with the results obtained by Newcomb from his discussion of the star densities in certain non-galactic regions of the Cordoba DM., after the application of systematic corrections to the registered magnitudes to reduce them to the Harvard photometric scale (*Astronomical Journal*, No. 507). These are added in column III.

Table III.

Magnitude.	I. (Galaxy.)	II. (Non-galactic.)	III. (Non-galactic.)
6·5	2·80	3·80	
			3·44
7·0	4·26	5·43	
7·5	5·74	4·68	2·39
8·0	6·81	5·20	
			2·40
8·5	5·72	4·33	
			3·48
9·0	7·67	5·16	
9·5	5·52	3·70	
			2·42
10·0	3·53	2·77	
			2·55

The relatively large values obtained here, as well as in Table I., for the C.P.D., as compared with Newcomb's results, are remarkable, pointing to a systematic difference in the scale of magnitudes respectively adopted.

The systematic corrections to the photographic magnitudes of the C.P.D. to reduce them to the visual magnitudes of Gould's Zone Catalogue, which are given by Kapteyn (*Annals of the Cape Observatory*, vol. v. p. 32), exhibit a similar discrepancy between the scales of the photographic and visual systems to that which is here disclosed. It will be remembered that Seeliger, in his discussion of the B.D. results, referred to above, found the value of the ratio in question to lie between 3 and 4 for the brighter stars. Seeliger's researches show that the ratio differs in different parts of the sky, and becomes exceptionally large in the galaxy itself, agreeing in this respect with the results for the relative values of the ratios given in columns I. and II. of Table III.

The publication of the authors' further discussion of the system of photographic magnitudes of the C.P.D. will be awaited with interest.

Note on the Principle of the Arithmetic Mean.

By H. C. Plummer, M.A.

1. In this note it is proposed to make a brief comparative study of certain lines of argument which are connected with the establishment of the arithmetic mean of a series of direct observations of a single quantity as the most plausible value to adopt. It has been suggested (by Encke, for example) that this position has been assigned to the arithmetic mean by experience, and even that the principle has an axiomatic character. This does not seem by any means to be the case. The arithmetic mean has always been, and probably always will be, adopted because it is by far the easiest function of the observations to calculate.* Also, although demonstrations of the principle may be wanting in rigour, its position has not been assailed by a rival more formidable in this respect or more acceptable on general grounds. If it be granted that positive and negative errors are equally likely to the same amount, it is obvious—and the formal remark has been made by Ellis †—that the arithmetic mean coincides with the true value in the limit when the number of observations is infinite. For if a is the true value, $x_1, x_2, \ldots$ the n observed quantities, and $e_1, e_2, \ldots$ the errors, then

$$\Sigma(x-a) = \Sigma e,$$

so that

$$a = \frac{\Sigma x}{n} - \frac{\Sigma e}{n} = \frac{\Sigma x}{n}.$$

* With the exception of the Median, advocated by Edgeworth (*Camb. Phil. Trans.*, 1889, and *Phil. Mag.*, 1887), and by Estienne in his *Etude sur les erreurs d observation*, Paris, 1890.

† *Camb. Phil. Trans.* vol. viii. p. 205 (1844).

But the axiom assumed cannot be supposed to hold generally. To consider a very simple example, let observations be made of the position of a point relatively to a scale. If the graduations are equidistant, the axiom will probably hold. If the scale is unequally divided, the axiom seems decidedly improbable. A proof of the principle of the arithmetic mean in the general sense seems therefore to be out of the question. It appears more philosophical to regard the hypotheses on which it has been sought to establish the principle not so much in the nature of axioms as of definitions in the simplest form of the properties which the observations must possess if the principle is to hold.

2. Two preliminary hypotheses which call for little remark may be given. The first is

Hypothesis I.—The function to be adopted is a symmetrical function of the observed quantities.

This must be admitted *a priori*, and must be allowed to stand *a posteriori* if the observations actually made are considered equally plausible. The second is

Hypothesis II.—The function is homogeneous and of the first degree.

This is necessary if the observations are to be allowed the first element of generality. For otherwise the result would not be independent of the unit of measurement.

3. Any function which satisfies these hypotheses, and which becomes identical with the common value of the observed quantities when these coincide, may be called *a* mean value. By the use of Taylor's Theorem De Morgan * expanded such a function in terms of an arbitrarily chosen magnitude and its deviations from the observed quantities. The terms of the first order reduce to the arithmetic mean of the observations, and he thus showed that every mean value consists of the arithmetic mean together with an aggregate of terms with regard to which we have no *a priori* knowledge. Ferrero † has followed the same order of thought, but has replaced the arbitrary magnitude by the arithmetic mean. He then pointed out that the coefficient of terms of the second order in the deviations in general bears a ratio to the reciprocal of n, the number of observations, which does not become infinite with n. He therefore concluded that every mean value approximates more closely to the arithmetic mean as the number of observations is increased and their accordance is improved.

4. A third hypothesis may now be added to the preceding. This is

Hypothesis III.—If all the measures are given any increment a, the most probable value of the quantity sought receives the same increment a.

In other words, the result is independent of the origin of

* *Camb. Phil. Trans.* vol. x. p. 416 (1864).

† *Esposizione del Metodo dei Minimi Quadrati*, p. 11 (1876).

measurement. If the most probable value be the function ϕ of the observed quantities $x_1, x_2, \ldots x_n$ the analytical expression of the third hypothesis is obtained at once by making the increment a infinitesimal in this form :

$$\frac{\partial \phi}{\partial x_1} + \frac{\partial \phi}{\partial x_2} + \cdots + \frac{\partial \phi}{\partial x_n} = 1 \qquad \ldots \qquad \ldots \qquad 1)$$

of which the integral is

$$\phi = \frac{1}{n}(x_1 + x_2 + \ldots + x_n) + \mathrm{F}(x_2 - x_1, x_3 - x_1, \ldots, x_n - x_1) \quad (2)$$
$$= \mathrm{M} + \mathrm{F}$$

where M is the arithmetic mean and F is a function of the differences of the observed quantities which satisfies hypotheses I and II. It must be noticed that there is no necessity to suppose that F is a rational and integral function. Otherwise F would vanish by virtue of hypothesis II. This point will be examined further in § 8.

5. The third hypothesis might be replaced by one expressed in a totally different form and yet equivalent to it—

Hypothesis III (a).—The law of facility of an error e can be expressed by a function of e.

Let $\psi(e)$ be the function to which the probability of an error e is proportional. If, then, z is the most probable result, the product

$$\psi(z - x_1)\, \psi(z - x_2) \ldots \psi(z - x_n)$$

is a maximum. Therefore

$$\frac{\psi'(z - x_1)}{\psi(z - x_1)} + \frac{\psi'(z - x_2)}{\psi(z - x_2)} + \cdots + \frac{\psi'(z - x_n)}{\psi(z - x_n)} = 0.$$

Now the form of this equation which z must satisfy shows immediately that z satisfies the conditions of hypothesis III. Hypotheses III and III (a) are therefore equivalent, and the latter imposes on z the form assigned to ϕ in (2). The geometric mean of the observed quantities, for example, is inconsistent with any law of facility. This has been remarked by Bertrand,* who deduced equation (1) from the fact that the functional determinant of

$$\phi - x_1, \ \phi - x_2, \ \ldots, \ \phi - x_n$$

vanishes. This argument seems rather to obscure the real simplicity of the result.

6. Bertrand † has also pointed out that the adoption of precise and independent definitions of the terms *precision* and *weight* suffices to restrict the form of the facility function. Let

* *Calcul des Probabilités*, p. 182 (1889).
† *Loc. cit.* p. 210.

the functions for two different series of observations be $\psi_1(e)$ and $\psi_2(e)$. Let the ratios of the precisions be h, and the ratio of the weights k, in the two series. The definitions of the terms are such as to imply that the ratios

$$\frac{\psi_1(he)}{\psi_2(e)} \text{ and } \frac{\psi_1(e)^k}{\psi_2(e)}$$

are constant. Accordingly

$$\psi_1(he) = \mathrm{G} \,.\, \psi_1(e)^k$$

where G is independent of e. The solution of this functional equation is

$$\psi_1(e) = \mathrm{C} \quad \exp.\,(-ae^\mu)$$

wherein

$$k = h^\mu, \ \mathrm{G} = \mathrm{C}^{1-k}$$

When $\mu = 2$ the solution gives the orthodox law of facility for which $k = h^2$. But any even values of μ would be equally consistent with definitions of precision and weight based respectively on the idea of equal probability of proportional errors in two systems of observations, and on the idea of the equivalence of a measure in one system to several identical measures in another.

7. It is not intended in this note to consider the form of the facility function as such. But with the general form found in § 6, the most probable value of the quantity sought from a series of observations must make

$$(z-x_1)^\mu + (z-x_2)^\mu + \ \ldots \ + (z-x_n)^\mu$$

a minimum, so that

$$(z-x_1)^{\mu-1} + (z-x_2)^{\mu-1} + \ \ldots \ + (z-x_n)^{\mu-1} = 0.$$

This equation, which clearly, since $\mu - 1$ is odd, has one and only one real solution, may be written in the form

$$(s_0, s_1, \ldots, s_{\mu-1})(z, -1)^{\mu-1} = 0,$$

where

$$s_r = x_1^r + x_2^r + \ \ldots \ + x_n^r.$$

In order to obtain a concrete example, let the case be considered in which $\mu = 4$. In the equation

$$(s_0, s_1, s_2, s_3)(z, -1)^3$$

let the roots be diminished by $\mathrm{M} = s_1/n$. The result is the transformed equation

$$s_0 y^3 + 3y\left(s_2 - \frac{s_1^2}{s_0}\right) - s_3 + \frac{3s_1 s_2}{s_0} - \frac{2s_1^3}{s_0^2} = 0.$$

The solution is

$$y = \alpha^{\frac{1}{3}} + \beta^{\frac{1}{3}},$$

where α, β are the roots of the quadratic

$$x^2 - \left[\frac{s_3}{s_0} - \frac{3s_1s_2}{s_0^2} + \frac{2s_1^3}{s_0^3}\right]x + \left[\frac{s_1^2}{s_0} - s_2\right]^3 = 0.$$

Hence

$$z = \mathrm{M} + \alpha^{\frac{1}{3}} + \beta^{\frac{1}{3}}$$

is a function which might be considered the most plausible to adopt as the value of the quantity measured, in the sense that it satisfies the hypotheses so far introduced and is not inherently impossible.

8. The function just found, although not an impossible one nor without a certain interest, has not been constructed for its own sake, but in order to prove by an actual example that hypotheses II and III do not suffice to limit the function of the observed quantities to the arithmetic mean. This is in direct contradiction to the conclusion of Ferrero,* who attempted to prove that the principle of the arithmetic mean was a necessary consequence of these postulates. It has already been noticed in § 4 that F cannot possess a rational and integral form. This suggests that there must be some tacit assumption underlying Ferrero's proof. It is introduced by the expansion of the function in terms of the arithmetic mean and its deviations from the observed quantities. The want of rigour in the proof is due to the assumption that the use of Taylor's Theorem is legitimate. Apparently the existence of functions which cannot be expanded by Taylor's Theorem has been ignored.

9. It is therefore necessary to seek another condition which must be satisfied by the most probable value of the observed quantity. The simplest one seems to be

Hypothesis IV.—The independent measures must be combined in such a way that an error which may exist in one of the measures, as x_1, shall produce the same error in the "value adopted as the most probable" as would be produced by the same error in x_2, x_3 or x_n.

The axiomatic character of this hypothesis does not seem to be obvious, but as an expression of a necessary property of the most probable value it is at least interesting. The condition is at once expressed in analytical form by making the error in $x_1, x_2, \ldots$ or x_n infinitesimal. The equations immediately obtained are

$$\frac{\partial \phi}{\partial x_1} = \frac{\partial \phi}{\partial x_2} = \frac{\partial \phi}{\partial x_3} = \ldots = \frac{\partial \phi}{\partial x_n} \quad \ldots \quad \ldots \quad (3)$$

* *Loc. cit.* p. 40.

The first equality gives at once

$$\phi = f(x_1 + x_2).$$

Hence

$$\frac{\partial\phi}{\partial x_1} = \frac{\partial\phi}{\partial x_2} = \frac{\partial\phi}{\partial(x_1 + x_2)} = \frac{\partial\phi}{\partial x_3},$$

and consequently

$$\phi = f(x_1 + x_2 + x_3).$$

Proceeding thus we obtain finally

$$\begin{aligned} \phi &= f(x_1 + x_2 + x_3 + \ldots + x_n) \\ &= \phi(\mathrm{M}) \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (4) \end{aligned}$$

and if ϕ is a function of invariable form, that form seems to follow most simply by supposing the observed quantities to coincide with a single value a. For then clearly

$$\phi(a) = a$$

and

$$\phi = \phi(\mathrm{M}) = \mathrm{M} \quad \ldots \quad \ldots \quad \ldots \quad (5)$$

Thus the principle of the arithmetic mean follows from the hypothesis.

10. Hypothesis IV is due to Stone,* in whose conception its truth seems to have possessed an intuitive character. His method of deducing the equation (4) seems needlessly complicated, and withal not altogether free from objection, as it involved the ex-expansion of the function by Taylor's Theorem. The completion of the proof of the principle in view was effected by the method of induction from the case when $n=2$. In this case, as Glaisher † has pointed out, the truth follows from the theory, though it may be remarked that the "theory" depends on the unproved assumption expressed in Hypothesis III (a). The use of the method of induction seems no more satisfactory and much less simple than the line of argument adopted in deducing equation (5) from equation (4).

11. The last proof of the principle of the arithmetic mean which will be noticed here is the one which is due to Schiaparelli.‡ As a basis of this proof he adopted Hypotheses II, III, and IV. The combination of equations (1) and (3) with the analytical expression of the second hypothesis by means of Euler's Theorem leads at once to the desired result. Schiaparelli arrived at the fourth hypothesis quite independently. It is interesting to notice that these two writers were led to adopt it from quite

* *Monthly Notices*, vol. xxxiii. p. 570 (1873).
† *Memoirs of the R.A.S.* vol. xxxix. p. 92 (1872).
‡ *Astr. Nachr.* Nr. 2068 (1875).

different points of view. As has been said, Stone attributed to the condition an *a priori* character. On the other hand, it appears from a later note * that Schiaparelli started with the necessary differential equations and then sought to give them as it were a physical interpretation. Thus Schiaparelli's proof appears frankly artificial, and confirms a remark, made earlier in the present note, that it may be wiser to regard the hypotheses as defining the properties which the observations must possess rather than as axioms on which a rigorous proof of the principle of the arithmetic mean can be founded.

12. I cannot conclude this brief note without expressing my indebtedness to that section of Emanuel Czuber's "Theorie der Beobachtungsfehler" which treats of the principle of the arithmetic mean, both for references and for a connected account of the main lines of earlier discussions of the subject.

University Observatory, Oxford:
1902 *May* 28.

Experimental Reduction of Photographs of Eros for the Determination of the Solar Parallax. Second Paper: *Combination of Results from Mount Hamilton, Minneapolis and Cambridge.* Arthur R. Hinks, M.A.

1. In a recent paper (*Monthly Notices*, 1901 November, vol. lxii. p. 22) I attempted to develop a somewhat new method of comparing with an ephemeris positions of a planet derived from measures upon photographs. Briefly the method was this: Separate heliocentric ephemerides of the planet and of the Earth are expressed in rectangular coordinates referred to a mean ecliptic and equinox, the unit being naturally the mean distance of the Sun from the Earth. From these two simple ephemerides (which arise in the process of computing the usual apparent place ephemeris) it is comparatively easy to compute the position of the planet upon a "standard" plate of given centre; the only transformation of coordinates which is not a mere addition, viz. the change from axes in and perpendicular to the ecliptic to axes in and perpendicular to the plate, is expressed in terms of direction cosines and performed with considerable ease on an arithmometer. In fact, the method offers the advantage that almost throughout the coordinates are rectangular, the transformations linear, and the numerical operations are consequently such as can be performed much more readily with a calculating machine than with logarithms.

2. For a trial of the method I measured and reduced fifty-two exposures of *Eros* made at Cambridge on 1900 November 9 and

* *Astr. Nachr.* Nr. 2097 (1876).

10. All the details of the reductions to standard, and of the method then used of comparing with the ephemeris computed for me by Professor E. Millosevich, will be found in the first paper. We need mention here only one point. In order satisfactorily to represent the observations it was necessary to correct the ephemeris by terms varying directly with the time. At the same hour angles on two successive nights the differences, computed minus observed position of the planet, were not the same. It seemed that the ephemeris would not represent the motion of the planet for so long a period as twenty-four hours, and in that case it would be clearly impossible to determine the parallax by the diurnal method from the results of any number of single disconnected nights. Parallactic shift and progressive error of the ephemeris are hopelessly interwoven, and nothing can be done unless we have observations at the same hour angles, and therefore with the same parallax factors, on adjacent nights. Then only can the progressive error of the ephemeris be separated from the parallax and empirically eliminated before proceeding to the solution of the equations of condition. It is clear, however, that this procedure breaks down unless the series of observations is fairly continuous—which in the winter of 1900–01 was by no means the case—and that in general a large part of the work of any observatory must be excluded from a parallax discussion of the results of that observatory alone.

The difficulty might be overcome by making a preliminary solution of all the results from all the co-operating observatories, deducing therefrom a series of corrections to the tabular place of the planet, and basing upon these a new ephemeris. This would represent the apparent motion of the planet very accurately. But Sir David Gill remarks, in his discussion of the heliometer observations of *Victoria*, that the resulting ephemeris must be looked upon rather as an interpolation formula than as the equivalent of a genuine orbit that will continue to represent the planet's motion for any length of time; wherefore he took his tabular places from the second ephemeris of *Victoria* and his tabular distances from the first; and there is the further disadvantage that a complete preliminary discussion for tabular errors of the ephemeris would delay for an indefinite time the deduction of any satisfactory value of the parallax; the mass of observations is too large and too heterogeneous to be dealt with in this laborious way.

But we have an obvious alternative. In every case of a pair of nearly simultaneous observations of *Eros* made at stations far apart, the tabular place of *Eros*, be it good or bad, is practically eliminated when it is a question only of finding the parallax, and not of correcting the ephemeris, and it seems that at first it will be better policy to aim at combining directly the observations in groups extending over so short a time that the errors of the ephemeris have no time to develop, rather than to work for a complete general reduction of the whole material at one

sweep. The photographs of *Eros* number so many thousands that we may expect to find a great many cases where the observations may be separated in this way into small groups. The aim of this paper is to apply to two or three such cases the method of reduction which was developed in the previous paper.

3. The publication in the Paris circulars of a detailed statement of what each observatory has achieved makes it very easy to select good examples of pairs of nearly simultaneous observations at stations far apart. I found that at three observatories in the United States—Lick, Minneapolis, and Northfield—they had plates taken very nearly at the same time as some of those of 1900 November 9 and 10 which I was reducing by the diurnal method. A request for early measures of these plates brought from the directors of the three observatories a very kind and ready response. The measurement of the photographs made at Mount Hamilton with the Crossley reflector had been undertaken by the Columbia University Observatory, New York; and at the request of Professor W. W. Campbell Professor J. K. Rees pushed forward the measurement of eight exposures of the planet and of selected comparison stars, and sent me the measures. Professor F. P. Leavenworth measured seven exposures made at the Observatory of the University of Minnesota, and Professor H. C. Wilson, Director of the Goodsell Observatory, replied that the plate I wanted had been spoiled by passing clouds, and was probably not worth measuring, but promised measures of any other plates that might be useful. To all my sincere thanks are due for the kindness with which they undertook to place at my disposal the material for this second experiment.

4. Meanwhile M. Loewy, President of the *Eros* Commission of the Paris International Conference of 1900, had undertaken to superintend the computation of an eight-figure ephemeris of *Eros* based upon the latest orbit of Professor Millosevich. It was to give, as usual, apparent R.A. and Decl. of the planet, but at my request he promised to print also the separate heliocentric ephemerides of the planet and of the Earth, expressed in rectangular coordinates referred to the mean ecliptic and equinox of 1900·0, which arise in the course of computation of the other ephemeris, and which are of the form most convenient for the method I am using. These ephemerides have recently appeared in the ninth *Paris circular*, and I must not fail to acknowledge my obligations to M. Loewy for the kindness with which he has taken much trouble to forward the trial of a plan very different from that which he himself prefers.

5. We must now reproduce briefly the expressions for the computed place of the planet upon our standard plate, whose centre is given.

Take three rectangular axes, with centre of Sun as origin, directed towards the mean equinox for 1900·0, the point in the ecliptic whose longitude is 90°, and the pole of the ecliptic. At an epoch T, when light left it, the coordinates of the planet on

this system are U, V, W ; at the epoch $T+\Delta T$ when that light reached the Earth the coordinates of the Earth are f, g, h. These six quantities, U, V, W ; f, g, h, are found by interpolation in the heliocentric ephemerides referred to above ; and $U-f$, $V-g$, $W-h$ are the coordinates of the planet at T as seen from the centre of the Earth at $T+\Delta T$.

Suppose now that we take a new system of rectangular axes through the centre of the Earth, parallel to the two axes of rectangular coordinates on the standard plate and to the normal to the plate ; and let l_1, m_1, n_1, &c., be the direction cosines of the new axes with respect to the old. Then the coordinates of the planet with respect to these new axes are

$$\begin{aligned} L &= l_1(U-f)+ l_2(V-g)+ l_3(W-h) \\ M &= m_1(U-f)+m_2(V-g)+m_3(W-h) \\ N &= n_1(U-f)+n_2(V-g)+ n_3(W-h) \end{aligned}$$

and, omitting for the moment the parallax terms, the coordinates of the planet on the standard plate are $\xi_0 = L/N$, $\eta_0 = M/N$.

The procedure adopted in the first paper was therefore as follows : Compute for each exposure T, $T+\Delta T$, and the corresponding interpolation coefficients, and thence the coordinates U, V, W ; f, g, h.

Compute once for all the nine direction cosines ; thence for each exposure the values of L, M, N ; and thence ξ_0, η_0.

Now all this involved a good deal of multiplication by direction cosines. Performed on the arithmometer the work was heavy, but I do not think heavier than in the alternative process of interpolating in the ephemeris for App. R.A. and Decl., and thence transforming to rectangular coordinates on the standard plate. The interpolation in the heliocentric ephemerides is much less troublesome ; but without an arithmometer the labour of the whole process would have been prohibitive.

6. It now seems to me that when we have to deal with a large number of exposures with approximately the same centering, or which have been reduced to the same standard plate, an altogether better plan is to start by constructing a "plate ephemeris" for that particular centre.

For the standard plate of 1900 Nov. 9 and 10 the coordinates of whose centre are α $1^h\,57^m\,8^s$ $\delta+54^\circ\,22'$ I have made a plate ephemeris as follows :—

f, g, h are the heliocentric ecliptic coordinates of the Earth for successive Berlin midnights taken directly from the ephemeris (*Paris circular*, No. 9, p. 194, where $f=-X$, $g=-Y$, $h=-Z$).

U, V, W are the heliocentric ecliptic coordinates of *Eros*, interpolated from the ephemeris of the planet, for successive epochs—Berlin midnight minus the aberration time.

The values of the direction cosines are :—

l_1 −·48912876	m_1 −·70890040	n_1 +·50814690
l_2 +·80015971	m_2 −·13284009	n_2 +·58489137
l_3 −·34712745	m_3 +·69268589	n_3 +·63220945

Thence we find for each Berlin midnight the values of L, M, N, and thence of ξ_0, η_0.

We have now an ephemeris which gives the standard coordinates on our plate (except for the parallax displacements which have not yet been put in) of the places of the planet at the times light left it as seen from the Earth at successive Berlin midnights when the light arrived. If we now interpolate in this ephemeris for the mean epochs of our exposures, and calculate the parallax displacements exactly as before (*Monthly Notices*, lxii. p. 30) we have what we want, the computed standard coordinates of the planet at the times the light left it, as seen from our position on the Earth at the times the light reached it.

Plate Ephemeris of Eros for Plate Centre, $1^h\ 57^m\ 8^s + 54°\ 22'\ 0''$ (1900-0).

1900.	ξ_0.	η_0.
Nov. 7	+·01472591	−·00060344
8	+·00947016	·00030762
9	+·00422788	·00027106
10	−·00098974	·00049666
11	−·00617220	·00098664
12	−·01130788	−·00174276

There is here a considerable saving of labour. We save the greater part of the computation of the epoch T and its interpolation coefficients ; of the interpolations for the six quantities U, V, W ; f, g, h ; of the long multiplications by direction cosines, and of the subsequent divisions by N ; for these operations have to be performed for six epochs only instead of perhaps a hundred. Eventually we have to interpolate for two quantities, standard coordinates instead of App. R.A.'s and Decl. ; and the labour of constructing the plate ephemeris to start with is much less than that of turning a large number of R.A.'s and Decls. into standard coordinates, especially when the former can be done on the arithmometer. Finally we are spared the labour of computing and taking out the correction to the planet's place for the aberration of light, which has in the ordinary course been automatically but improperly introduced by the process of reduction (see Mr. Cowell's paper in *The Observatory*, 1900 December, and mine, *Monthly Notices*, lxii. p. 29).

7. The reduction to standard of the Cambridge exposures

has been done in two steps. An exposure near the meridian on Nov. 10 was selected as a "zero exposure," and all the exposures of the series A (guiding on the stars) were first reduced to this by the six constant formulæ (Turner's), with constants derived from the measures of fourteen comparison stars nearly equal to the planet in magnitude. All were then reduced from zero to standard by the constants derived from measures of thirteen meridian standard stars on the zero plate.

In the present reductions I have taken the mean of all the plates of series A reduced to zero as a new zero plate, with the purpose of avoiding systematic errors in the constants of reduction to zero which might arise from accidental errors in the old single zero plate. We will call this the mean zero plate.

The constants of the reduction from mean zero to standard were derived from the seven stars on the plate which have been observed by a great number of observatories as *étoiles de repère* for the *Eros* plates (*Paris circulars* 8 and 9). The number is small for two reasons : first, that the Paris list was selected for the astrographic plates of 2° square, and a number of stars lie just outside the edge of my plates, which cover only $1\frac{1}{2}°$ square ; second, that two of the Paris stars are not available, one because it is so bright that adjacent images interfere with one another, the other because it is unfortunately the variable *U Persei*, which was faint at the time that *Eros* passed near it. By bad luck these two stars were especially wanted to give a good determination of the scale value in ξ ; and I am not satisfied that a part of the apparent increase of the tabular error of the ephemeris with the time may not be due to erroneous scale value. This would be fatal to a determination of the parallax by the diurnal method, but is easily seen to have no sensible effect on the present reductions.

8. I have chosen deliberately to retain the six constants in the reduction, that is, to admit a possible difference of scale value in the directions of the two axes of coordinates, rather than to calculate and apply the whole or the unsymmetrical part of the differential refraction, and thus reduce the constants required by theory to four. The argument of those who contend for the latter procedure appears to be that when the unsymmetrical part of the refraction is removed all the remaining necessary corrections ought to be, and therefore are, symmetrical. In reply to this I would urge that in actual fact they frequently are not. Time after time I have found that the asymmetry of the six constants found by the direct reduction, according to Turner, does not correspond at all with the asymmetry produced by the differential refraction. Pending the collection of more material for an examination of this point, one may do either of two things :— use six constants and secure the best fit possible between two plates to be compared, or use four and be satisfied with a fit not the best possible, but the best consistent with the hypothesis of symmetry. I think that there can be no doubt that the former

is the more prudent course, and am not at present prepared to admit that the use of the six constants involves any loss of weight or of rigour.

9. The following are the details of the photographs used in the present discussion.

Lick. Crossley Reflector. Aperture 3 ft.; focal l. 17 ft. 6 in.

Plate No.	Epoch of Mid. Exp.	h	m	s	Duration of Exp. s	No. of Comp. Stars.
461 (1)	G.M.T. Nov. 9	15	18	15	10	6
(5)		15	19	50	20	6
462 (3)		15	24	5	10	6
472 (1)	Nov. 10	14	16	15	10	7
(3)		14	16	57·5	15	7
480 (1)		14	50	15	10	7
(3)		14	50	57·5	15	7

Minneapolis. Refractor. Aperture 10½ in.; focal l. 11 ft. 3 in.

		h	m	s	m	s	
1	Nov. 10	13	52	6	2	0	14
3		14	3	49	3	30	14

Cambridge. Refractor. Aperture 12½ in.; focal l. 19 ft. 2 in.

		h	m	s	m	
246	Nov. 9	15	36	1	3	14
247		15	39	51	2	„
250		16	35	21	3	„
251		16	38	11	2	„
274	Nov. 10	12	39	29	3	„
275		12	42	24	2	„
278		13	37	24	3	„
279		13	40	19	2	„
282		14	40	54	3	„
283		14	44	24	2	„

After a preliminary reduction of the Lick and Minneapolis measures to the scale of the Cambridge plates the equations of condition were formed to reduce each exposure to the Cambridge mean zero plate, the six constants were found for each exposure, and the measures of the planet reduced to Cambridge mean zero, and thence to standard by the constants derived from the reduction of the mean zero plate to standard with the new places of the *étoiles de repère* from the Paris circulars. These standard places of the planet are next expressed in parts of the radius of projection, and thenceforward the unit to be employed

is 1×10^{-7} of the radius. It has been assumed for the present that the weight of each plate is the same.

Since we are concerned more with methods than with numerical results, it is unnecessary to print the details of the measures and reductions.

10. Neither is it necessary to follow in detail the steps required to form the equations of condition. The tabular places of the planet were interpolated from the "plate ephemeris"; the parallax factors were found as in the previous paper (*Monthly Notices*, vol. lxii. p. 30); the tabular places were corrected for parallax with an assumed value of the solar parallax, and compared with the observed places. Finally means were taken of pairs of observations close together, which are then treated as one observation.

If $\Delta\pi$ is the correction required to the assumed value of the solar parallax, $\Delta\xi_0$ and $\Delta\eta_0$ the corrections to the plate ephemeris supposed constant for the two short periods under discussion, we have the following equations of condition :—

Nov. 9.					Residuals.
Camb. 246,7	$+1{\cdot}56\,\Delta\pi$	$-1\,\Delta\xi_0$	$0\,\Delta\eta_0$	$-90=0$	− 3
	+0·86	0	−1	+ 5	+ 7
250,1	+1·62	−1	0	−80	+ 7
	+1·19	0	−1	−16	−14
Lick 461 (1, 5)	−1·68	−1	0	−85	− 1
	−0·11	0	−1	+ 5	+ 6
462 (3)	−1·65	−1	0	−87	− 2
	−0·15	0	−1	+ 2	+ 2

The last two equations, being dependent upon one exposure only, have been given half weight.

Nov. 10.					Residuals.
Camb. 274,5	$+0{\cdot}84\,\Delta\pi$	$-1\,\Delta\xi_0$	$0\,\Delta\eta_0$	$-72=0$	+1
	+0·08	0	−1	−27	+3
278,9	+1·17	−1	0	−69	+3
	+0·29	0	−1	−28	+2
282,3	+1·44	−1	0	−73	−2
	+0·59	0	−1	−27	+2
Lick 472 (1, 3)	−1·96	−1	0	−77	+5
	+0·27	0	−1	−31	−1
480 (1, 3)	−1·81	−1	0	−83	−1
	+0·04	0	−1	−31	0
Minn. 1, 3	−1·30	−1	0	−86	−6
	−0·01	0	−1	−36	−5

The normal equations derived from these are :—

Nov. 9.	$+11{\cdot}43\,\Delta\pi$	$-0{\cdot}67\,\Delta\xi_0$	$-1{\cdot}86\,\Delta\eta_0$	$-\ 70=0$
	$-\ 0{\cdot}67\,\Delta\pi$	$+3{\cdot}50\,\Delta\xi_0$	$0{\cdot}00\,\Delta\eta_0$	$+299=0$
	$-\ 1{\cdot}86\,\Delta\pi$	$0{\cdot}00\,\Delta\xi_0$	$+3{\cdot}50\,\Delta\eta_0$	$+\ 5=0$
Nov. 10.	$+13{\cdot}47\,\Delta\pi$	$+1{\cdot}62\,\Delta\xi_0$	$-1{\cdot}26\,\Delta\eta_0$	$+131=0$
	$+\ 1{\cdot}62\,\Delta\pi$	$+6{\cdot}00\,\Delta\xi_0$	$0{\cdot}00\,\Delta\eta_0$	$+460=0$
	$-\ 1{\cdot}26\,\Delta\pi$	$0{\cdot}00\,\Delta\xi_0$	$+6{\cdot}00\,\Delta\eta_0$	$+180=0$

Eliminating successively $\Delta\xi_0$ and $\Delta\eta_0$ from each of these sets we obtain two equations for $\Delta\pi$.

From Nov. 9.	$+10{\cdot}31\,\Delta\pi=+10$
Nov. 10.	$+12{\cdot}77\,\Delta\pi=-45.$

Assuming that the p.e. of an equation of weight unity is the same on each night we add these together, and find

$$\Delta\pi=-1{\cdot}5 \qquad =-0''{\cdot}031.$$

If we carry out the solutions separately for each day we obtain

For November	9	$\Delta\xi_0=-85$	$\Delta\eta_0=-\ 1$	$\Delta\pi=+0{\cdot}97$
	10	$\Delta\xi_0=-76$	$\Delta\eta_0=-31$	$\Delta\pi=-3{\cdot}52$

and substituting back in the equations of condition we obtain the residuals given in the last column.

From these we find

P.E. of one equation of weight unity

November	9	$\pm5{\cdot}6$	$=\pm0''{\cdot}11$
	10	$\pm2{\cdot}4$	$=\pm0''{\cdot}05$

The great difference between the apparent weights for the two nights is caused almost entirely by the discrepant Cambridge observation in η on November 9 (the fourth equation of condition). On the other hand, perhaps the observations of November 10 are unusually accordant. We may take for the present the p.e. of one equation of weight unity, derived from the mean of a pair of exposures, as about $\pm\ 0''{\cdot}07$; and it is scarcely worth while to examine minutely the probable errors of the quantities derived from so few equations.

The differences between the corrections to the tabular places on November 9 and 10 come out rather large, and it is not possible with this small amount of material to say how far they are real. But they emphasise the necessity for dividing the equations, as has been done here, into groups derived from observations nearly simultaneous.

I have refrained from giving the assumed value of the parallax to which these observations give the above correction, because no good purpose can be served by publishing preliminary results which have but little weight.

11. In summing up the conclusions which may be drawn from these two experimental reductions of *Eros* photographs I would submit.

(1) That the adopted form of ephemeris in rectangular coordinates has been found convenient, and may be used in future definitive reductions.

(2) That the direct comparison of simultaneous photographs by linear reductions is the most convenient method of dealing with the *Eros* plates. If the same comparison stars are used, it is not required that their meridian places should all be known; if the meridian places of the comparatively few standard stars are not quite accurate, the resulting parallax is scarcely affected; if the ephemeris needs correction by terms varying with the time, practically no harm is done. In fact, by working in this way we can find the parallax by methods which are differential, and do not involve absolute places, except in a secondary degree. The gain is obvious.

(3) The smallness of the probable error of an equation of condition is satisfactory evidence of the value of photographic methods for finding the solar parallax. If the results of a larger series come out as well as those that have been discussed here, that is to say, if the p.e. of an equation of condition derived from the mean of two exposures is about $\pm 0''\cdot07$, we shall not want to discuss the whole of the existing material to obtain a value of the solar parallax with a p.e. $\pm 0''\cdot005$, which is the value Gill finds for the p.e. of his determination from the heliometer observations of *Victoria*, *Iris*, and *Sappho*. It will be a matter of great interest to see whether the photographic observations of *Eros* confirm this result, which has just been adopted by the Nautical Almanacs, or bring out a smaller value, more in accordance with that required by the planetary theory, and by recent determinations of the constant of aberration combined with the velocity of light.

The sooner this can be done the better. I think, therefore, that our next step should be to extend the limits of these reductions so as to include enough material to give us a value of the solar parallax with a p.e. less than $\pm 0''\cdot005$. We propose to measure next all our Cambridge plates between 1900 November 7 and 15 inclusive, and to combine them with as many simultaneous exposures made at other observatories as may be available. To this end I should like to propose to seven or eight observatories spread over as long an arc of longitude as possible that we should agree upon a common list of comparison stars, and measure up all our plates in that period of nine days. If we can concentrate our attention upon this block of the work the measurement is not so formidable a task as to consume a great

many months. Then when the measures are made we might publish or interchange this raw material and proceed to its discussion.

It should be possible thus to settle in two or three years the question whether or not *Eros* is going to give us the same value of the solar parallax as did the three other less happily situated minor planets. That, I take it, is the main point. If it does not, and we have to proceed eventually to the discussion of the whole mass of material, we shall have gained experience and lost no time by concentrating our energies at first upon a few days' plates.

I must add that my sincere thanks are due to the directors of the Lick Observatory, of the Columbia University Observatory, and of the Oxford University Observatory, who have already cordially agreed to enter into this plan.

Cambridge Observatory:
1902 *June* 9.

Reductions of photographs of Swift's Comet (*a* 1899), *taken at the Cambridge Observatory, with a portrait lens.* By L. N. G. Filon, M.A., B.Sc.

1. In the summer of 1899 I was working at the Cambridge Observatory, and I undertook to help Mr. A. R. Hinks in taking some photographic observations of Swift's Comet *a* 1899, which was visible during May and the beginning of June as a telescopic object.

The plates taken then had perforce to remain unmeasured for a long time, as the present measuring machine of Cambridge Observatory was still in course of construction, and it was nearly eighteen months before it was ready for use. Stress of other work, however, and the fact that the machine was urgently needed at the Observatory for the measurement of the Eros parallax plates prevented my attending at the time to the reduction of these observations.

In February last the machine was available, and the plates capable of measurement were then measured and reduced. The results of the reduction are presented in this paper.

The photographs of the comet were taken with a portrait lens, of about 30 inches focal length and 5 inches aperture, stopped down to work at $f/8$. The portrait lens and its camera, for the loan of which I understand the Observatory was indebted to Professor Turner, were fixed to the tube of the Northumberland Equatorial, which was used as a guiding telescope. The camera was placed at the object-glass end of the telescope. An exposing shutter could be opened and shut from the eye end by pulling a string attached for the purpose.

Apart, then, from any intrinsic value which the comet places found from these observations may possess, the reductions appear to present considerable interest as showing what sort of accuracy may be expected from measures of stars upon plates taken with an ordinary portrait lens. I believe that hitherto this method has not been seriously considered as a means of obtaining accurate places of stars. Many observers, who have not at their disposal a large photographic telescope, may, and do, use portrait lenses. It appeared important to find out whether photographs taken in this way would repay the labour of measurement and reduction.

2. Between May 15 and June 14 eighteen plates in all were taken of the comet, the first eight (May 19–May 25) by Mr. Hinks and the last ten (May 25–June 14) by myself. Of these eighteen plates seven were long exposures taken with the stars trailing and varying from 15 to 109 minutes. Of the remaining eleven plates two were taken through breaks in the clouds, and were not considered good enough for measurement; one, a plate taken on June 14, when the comet was fast receding from the Earth and had become very faint indeed, showed no visible image of the comet after two years. Finally one plate was accidentally broken during the measurements. This left seven plates with measurable images, carrying in all twenty-six exposures, varying from one to eight minutes, as follows :—

Plate No.	Date 1899.	Exposure (*a*).	Exposure (*b*).	Exposure (*c*).
		h m s m s	h m s m s	h m s m s
5	May 19	15 48 35 − 50 35	15 51 10½ − ...	15 53 48 − 55 48
7	23	17 34 20 − 39 20	17 41 20 − 46 20	17 47 6 − 54 6
10	26	16 35 55 − 39 55	17 5 2 − 9 2	17 13 0 − 19 0
11	29	18 2 40 − 5 40	18 6 45 − 10 45	18 11 52 − 15 52
14	31	16 10 8 − 14 8	16 19 32 − 23 32	16 24 45 − 30 45
16	June 3	18 27 0 − 32 0	18 33 0 − 41 0	...
17	5	17 38 0 − 43 0	17 44 0 − 49 0	17 50 0 − 58 0

The times given in the above are the Cambridge sidereal times of beginning and end of each exposure. All the above exposures were measured, excepting *b* of plate 5.

3. A very full description of the Cambridge measuring machine and of the method of using it has been given to the Royal Astronomical Society by Mr. Hinks (*Monthly Notices*, 1901 May, vol. lxi. p. 444). There is accordingly no need to repeat here what he has said.

A special difficulty, however, occurred in my case, as two of the plates had no réseau on them, and the Cambridge machine is exclusively adapted for measuring plates with a réseau. The difficulty was solved by placing another plate, provided with a réseau, but otherwise blank, upon the plate to be measured.

The two plates were cemented face to face with a little shellac varnish at the corners. This arrangement was found to work perfectly, the only effect of the thickness of glass introduced being to decrease the effective distance of the plate from the object-glass. Accordingly the focus had to be altered and the scale-value was somewhat different; the latter, however, can be adjusted in the Cambridge machine, so that no inconvenience arose on this score.

Effects of distortion in passing through the plate of glass were calculated and found to be quite negligible to the order of accuracy required for the measurements; and, indeed, these two plates have given results quite as satisfactory as the others. This would tend to confirm that the errors of the gelatine film, which the réseau was originally intended to obviate, are practically nil.

This seemed worth pointing out, because it may occasionally, for some reason or other, be impossible for an observer to have a réseau. Such photographs need not therefore be rejected for measurement.

4. In making the measures two or one settings were made on each réseau line, according as the latter was faint or distinct; generally two settings were made on a star image and three to seven settings on a comet image, according to the degree of faintness or diffuseness. The measures were repeated with

Exposure (*d*).						Exposure (*e*).					Remarks.
h	m	s	h	m	s	h	m	s	m	s	
15	57	5	— 16	1	5	16	1	46½	— 2	46½	Clouds for (*b*); no réseau.
		...						...			Réseau.
17	21	0	—	25	0			...			No réseau.
18	19	7	—	25	7			...			Réseau.
16	31	55	—	37	55			...			Réseau. Images faint, difficult to measure.
		...						...			Réseau.
18	3	0	—	8	0			...			Réseau.

the plate reversed, and the mean of the direct and reversed measures, corrected for run, was taken as the coordinate of image upon the plate.

The settings on any one réseau line and on any one star image were, as a rule, fairly concordant; those on the comet occasionally differed widely.

The divergences of settings in the respective cases of the comet and of a star are illustrated in Table I., taken from the measurements of Plate 14, where the comet images are faint. Only the micrometer head readings are given, as they alone, of course, exhibit differences.

TABLE I.

(*Coordinate y, Pl.* 14.)

	Exposure (*d*). Dir.	Exposure (*d*). Rev.	Exposure (*c*). Dir.	Exposure (*c*). Rev.	Exposure (*b*). Dir.	Exposure (*b*). Rev.	Exposure (*a*). Dir.	Exposure (*a*). Rev.
Comet	120	352	578	850	528	902	234	158
	101	375	585	772	496	938	156	165
	085	369	570	871	502	925	212	186
	120	365	547	850	526	920	245	162
	098	...	550	850	500	...	210	...
Star 1	240	214	200	263	267	288	300	260
	239	210	200	254	265	282	299	262
Star 2	209	222	297	238	266	170	290	138
	208	220	302	231	264	170	290	143
Star 3	290	172	250	208	187	268	220	240
	286	170	251	212	190	265	210	240
Star 4	284	351	378	379	310	322	320	297
	280	353	372	364	310	325	330	290
Star 5	247	342	208	368	267	295	298	378
	242	346	212	362	274	292	302	373
Star 6	241	441	310	470	289	460	320	522
	240	436	310	470	290	452	322	524
Star 7	266	602	335	530	290	580	313	549
	269	600	340	530	290	580	311	548
Star 8	320	426	305	400	372	424	293	389
	320	426	302	396	370	423	295	391
Star 9	384	330	352	354	402	409	330	367
	379	336	352	356	399	407	322	369
Star 10	322	330	290	367	350	404	280	373
	330	327	286	363	349	403	278	371

From the residuals of the comet readings from the mean of each group the probable error of a setting on the comet is found to be about 15 ten-thousandths of a réseau interval. The focal length being nearly 150 réseau intervals, this corresponds to an error of about 2″.

On the other hand the probable error of a star setting, obtained by taking $\frac{1}{\sqrt{2}}$ (mean difference of two settings) is found to be about 2 in the last place, *i.e.* about 0″·3.

The differences between measures of the coordinate y on the same plate, taken in the direct and reversed positions, are shown in Table II.

TABLE II.

(*Coordinate y, Pl.* 14.)

	Exposure (*a*).		Exposure (*b*)		Exposure (*c*).		Exposure (*d*).	
	Dir.	Rev.	Dir.	Rev.	Dir.	Rev.	Dir.	Rev.
Comet	20·6552	20·6588	20·3847	20·3833	20·1903	20·1921	20·0431	20·0393
Star 1	23·6572	23·6563	23·4236	23·4235	23·2671	23·2663	23·1511	23·1512
Star 2	20·4742	20·4739	20·2415	20·2414	20·0852	20·0849	19·9685	19·9679
Star 3	24·2365	24·2363	24·0035	24·0041	23·8476	23·8471	23·7312	23·7310
Star 4	19·8425	19·8425	19·6107	19·6101	19·4574	19·4552	19·3382	19·3370
Star 5	20·4538	20·4531	20·2211	20·2216	20·0652	20·0642	19·9486	19·9484
Star 6	22·3039	22·3042	22·0705	22·0705	21·9148	21·9142	21·7980	21·7971
Star 7	18·8496	18·8501	18·6172	18·6168	18·4624	18·4619	18·3458	18·3450
Star 8	17·4391	17·4394	17·2063	17·2057	17·0496	17·0492	16·9334	16·9337
Star 9	20·8389	20·8397	20·6064	20·6053	20·4515	20·4511	20·3341	20·3331
Star 10	16·9279	16·9278	16·6950	16·6946	16·5385	16·5385	16·4227	16·4220

On looking at Table II. we see that for the stars there appears to be a systematic error due to orientation of the plate. Out of forty differences (direct–reversed) only seven are negative. Moreover, the mean value of the numerical difference = 5·4 in the last place = 0″·7 about. The value of the same quantity, calculated from the probable error of a setting, is only about 0″·4.

But it does not necessarily follow that all the systematic error will be eliminated by taking means. In other plates the difference (direct–reversed) shows a large predominance of negative values, showing that the systematic error, if such there be, is not constant, but varies slowly with the time. The error will only be eliminated in so far as it remains constant in the interval (frequently 24 hours or more) between the direct and the reversed measures.

The agreement, however, is sufficient to show us that the probable error of a measurement of an actual star image in this case is well under half a second of arc.

For the comet the mean numerical difference (direct–reversed) = 26 in the last place. If the difference were an accidental one of the same kind as that between settings in the same orientation, the value should be 21. There being only four such differences to form the mean in this case, the discrepancy seems hardly significant. Moreover, for the comet the difference (direct–reversed) is as much positive as negative, suggesting that the large amount of this difference for the comet is chiefly made up of accidental errors. The suggestion is confirmed by the examination of the differences for comet images on other plates.

5. The stars on the plate having been identified by means of a tracing from the Bonn Durchmusterung Charts, a certain

number, varying from 6 to 10, were selected, such that the mean of the group roughly coincided with the position of the comet.

These stars were taken as comparison stars, and their co-ordinates, as well as those of the comet, were measured for each exposure.

The centre of the plate was obtained by a rough measurement, and a value assumed for its R.A. and Decl. for each plate. The same position of the assumed centre was used for the various exposures on the same plate, this being found amply sufficient.

The comparison stars were then identified in the Helsingfors, Harvard, and Bonn Zone Catalogues, and their R.A.'s and declinations, brought up for precession to the epoch 1899·0, were found.

Their coordinates ξ, η upon an ideally correct plate having the assumed centering and an assumed scale value l, which was taken to be 150 from a first approximate determination, were calculated.

It then became necessary in all the cases where the plate had originally a réseau, to apply a large orientation correction to the measured coordinates, because the camera had to be attached to the equatorial in such a way that the edges of the plate, to which the lines of the réseau are approximately parallel, made an angle of nearly 45° with the plane through the polar axis.

This orientation correction was determined well within a degree by plotting the measured coordinates $x'y'$ of the stars on tracing paper, and also plotting the calculated coordinates (ξ, η) on another piece of tracing paper. By superposing the two sets of images the angle between the axes of ξ and x' could be read off with ease.

If this angle is θ, and if (x, y) denote the coordinates of any star approximately corrected for orientation, we have

$$x = x' \cos\theta - y' \sin\theta$$
$$y = y' \cos\theta + x' \sin\theta$$

In the case of the two plates 5 and 10, which were measured by fixing on to them another plate provided with a réseau, this difficulty did not occur, for the réseau was carefully placed in approximately the right position.

But the obliquity of the coordinates for the five plates which had originally a réseau was in reality an advantage, because the displacement of the images in passing from one exposure to another having been obtained by turning the slow-motion screw in declination, the various images, instead of lying on a line nearly parallel to a réseau line, were arranged upon a line making an angle of 45° with the réseau lines. This arrangement has recently been suggested by M. Loewy as desirable, and Mr. Hinks has strongly supported this view on the ground that any local defect in a réseau line did not then affect the measures of one coordinate for all the exposures.

6. The coordinates x, y having been obtained for each star and each exposure, the differences

$$\Delta x = \xi - x \qquad \Delta y = \eta - y$$

were written down.

The plate constants were obtained from the solution of the equations of condition by Dyson's approximate method.

It has been shown by Professor Turner (*Monthly Notices*, 1894, vol. liv. p. 489) and by Mr. Hinks ("The Methods of Reduction and Publication of Measures of Celestial Photographs" (*Astronomical Journal*, No. 475)) that this method gives practically as good values of the constants as the least square solution, the labour being much less.

I have accordingly adopted it in the present case. I have also adhered to the use of the six constants for the reduction of a plate. Theoretically, apart from a certain term due to the refraction, we should have

$$a = e,\ b = -d.$$

Sir David Gill urges that the unsymmetrical part of the refraction correction should be first applied and the equations of condition solved for four unknowns. As authorities appear to be divided on this point, it seemed safer, as well as more straightforward, to retain the six constants.

The values of the constants a, b, d, e, calculated separately for each of the 25 exposures measured, are as follows :—

Table III.

Plate.	Exposure	Plate Constants. a	b	d	e
5	(*a*)	+·00743	−·00769	+·00870	+·0072
	(*c*)	+·00738	−·00782	+·00885	+·00686
	(*d*)	+·00726	−·00783	+·00862	+·00674
	(*e*)	+·00715	−·00789	+·00866	+·00649
7	(*a*)	+·00592	−·01976	+·01955	+·00536
	(*b*)	+·00549	−·01951	+·01963	+·00545
	(*c*)	+·00522	−·01974	+·01947	+·00547
10	(*a*)	+·00527	+·03401	−·03399	+·00522
	(*b*)	+·00519	+·03228	−·03215	+·00486
	(*c*)	+·00547	+·03219	−·03231	+·00540
	(*d*)	+·00530	+·03229	−·03250	+·00529
11	(*a*)	+·00603	−·00924	+·00924	+·00606
	(*b*)	+·00646	−·00900	+·00902	+·00633
	(*c*)	+·00621	−·00897	+·00900	+·00609
	(*d*)	+·00612	−·00888	+·00928	+·00655

Plate.	Exposure.	Plate Constants.			
		a	*b*	*d*	*e*
14	(*a*)	+·00505	−·04563	+·04574	+·00497
	(*b*)	+·00519	−·04569	+·04553	+·00487
	(*c*)	+·00516	−·04562	+·04572	+·00497
	(*d*)	+·00515	−·04550	+·04546	+·00495
16	(*a*)	+·00576	−·00524	+·00693	+·00573
	(*b*)	+·00712	−·00636	+·00690	+·00536
17	(*a*)	+·00610	−·02339	+·02350	+·00586
	(*b*)	+·00574	−·02312	+·02311	+·00588
	(*c*)	+·00596	−·02305	+·02296	+·00589
	(*d*)	+·00588	−·02313	+·02298	+·00607

The above table shows that the effect of the differential refraction is small as a rule. The relations $a = e$, $b = -d$ are in the majority of cases approximately satisfied, but it should be noted that the plates were taken near the zenith.

One other conclusion comes out from these results, and that is that the plate constants are practically the same for all the exposures on one plate. The assumed centre and the large original orientation correction being in each case the same for all the exposures, we see that the constants a, b, d, e differ very little as we pass from one exposure to another.

There are one or two striking differences, such as b and d of 10 (a) as compared with the other exposures of 10 and the divergence between the constants of 16 (a) and 16 (b). In the case of 10 the probable cause may have been a slight shake which altered the orientation between exposures (a) and (b).

With regard to 16, no explanation occurs immediately; 16, however, is not a satisfactory plate. The agreement between the actual and calculated Δx's and Δy's for this plate is bad, as will be seen later on; and it appears probable that the conditions were unfavourable on the night when it was taken.

Thus we may take it that, barring shake or accidents of this kind, it is in general perfectly safe to reduce several exposures on the same plate by means of a single set of plate constants a, b, d, e; c and f, of course, varying for each exposure.

7. The values of Δx, Δy for each star were calculated from the plate constants for a number of the exposures. These calculated values were compared with the actual. The results are exhibited in tables IV. and V.

O—C denotes the excess of the observed coordinate of a star over its coordinate calculated from the plate constants.

TABLE IV.

x-coordinate.

O−C.

Exposure.	Star 1	Star 2	Star 3	Star 4	Star 5	Star 6	Star 7	Star 8	Star 9	Star 10	Probable error deduced
5*a*	− 5	− 4	+ 1	−36	+23	+ 7	− 5	− 4	+22	...	11·9
5*c*	0	−10	+ 9	−34	+15	+ 7	− 4	0	+24	...	11·4
7*c*	+ 5	+ 6	− 4	+ 4	− 9	− 6	− 4	+ 7	...	...	5·6
10*a*	+ 6	+ 6	− 8	− 2	− 2	− 4	+ 4	...	...	...	4·6
10*b*	+10	−11	+ 5	+ 3	− 4	0	− 3	...	...	...	5·1
10*c*	+10	0	−16	+ 4	+ 6	− 8	+ 5	...	...	...	7·0
10*d*	0	− 6	+ 4	+ 1	+ 2	+ 5	− 5	...	...	...	3·3
11*a*	+11	−16	−19	+16	− 2	− 9	+12	− 6	+12	...	11·4
11*d*	−24	+ 3	−10	+ 6	− 6	+ 1	+24	0	+ 6	...	8·9
14*b*	0	+ 7	+ 3	+ 6	−23	+ 7	+ 3	−17	+ 9	+ 6	8·1
14*d*	−12	0	− 4	+14	−16	+ 9	+ 4	−18	+12	+11	10·0
16*a*	−30	−21	− 5	−14	+ 6	− 6	+ 1	+43	+27	...	17·0
16*b*	+11	− 5	− 8	+ 2	−20	− 7	−28	+50	+ 6	...	15·2
17*a*	+ 6	+ 3	− 8	+15	− 8	− 7	...	...	...	...	7·8

TABLE V.

y-coordinate.

O−C.

Exposure.	Star 1	Star 2	Star 3	Star 4	Star 5	Star 6	Star 7	Star 8	Star 9	Star 10	Probable error deduced
5*a*	+13	− 9	−19	− 7	− 7	+16	+ 1	−10	+20	...	11·3
5*c*	+11	− 6	− 5	− 6	0	+18	+ 2	−24	+11	...	9·2
7*c*	− 8	0	+ 2	+ 5	+ 3	− 7	+ 2	+ 2	...	...	3·6
10*a*	− 3	− 2	− 6	+13	+10	+12	−23	...	...	...	9·9
10*b*	+16	−19	−22	+20	+26	+ 3	−24	...	...	...	18·6
10*c*	+ 8	−12	−14	+14	+20	+ 4	−19	...	...	...	13·0
10*d*	− 1	− 4	− 4	+14	+10	+ 5	−21	...	...	...	8·4
11*a*	+16	+ 8	−35	−10	−12	+16	+14	+ 5	− 4	...	13·3
11*d*	+ 9	+31	−35	−17	− 6	+26	+13	− 2	−19	...	17·6
14*b*	−12	− 8	+20	+ 1	+ 4	− 5	+10	+ 8	+13	−33	11·4
14*d*	−16	− 1	+25	− 8	+ 1	− 2	− 6	+15	+21	−25	12·0
16*a*	+42	+ 6	−48	−26	−23	0	+23	0	+26	...	21·6
16*b*	+42	+10	−27	−24	−32	− 5	+14	− 6	+30	...	21·1
17*a*	+ 4	+ 2	− 6	+10	− 6	− 3	...	...	...	...	5·2

I have tested the several exposures on one plate when the agreement seemed imperfect in order to see whether the discrepancies were due to local errors in the plate. A glance at the above tables, however, shows that this is not the case. Plates as a whole appear to show a high or small probable error. On investigation of the residuals it will generally be found that the large residuals, which raise the probable error, have the same sign and affect the same stars for all the exposures on one plate.

It appears, therefore, that the divergence resides in the star itself; it may be due to either of two causes: (i.) possible proper motion of the star, which the corrections deduced from the plate constants cannot, of course, allow for: (ii.) errors in the meridian places used. I suspected that the latter might probably not be relied upon much beyond a second of arc, and, in the computed places, only the nearest tenth of a second of R.A., and the nearest second of arc in declination were retained.

Accordingly the quantities ξ and η might themselves be out by something of the order of a second of arc, which is about ·00073 of a réseau interval, or about 7 in the last place. The event, as is shown further, has proved that this was a low estimate.

Excepting in the case of plate 16, which, as stated previously, is unsatisfactory, and of one exposure of 10, *all* the mean divergences amount to less than 2″, and in the case of plates like 7 and 17, for which the conditions appear to have been favourable, the mean divergences are under 1″. For the seven plates these mean divergences are as follows:—

$$\text{Probable divergence in } x = 9{\cdot}36 = 1''{\cdot}28$$
$$\text{,,} \qquad \text{,,} \qquad y = 10{\cdot}87 = 1''{\cdot}49$$

where, not to weight unduly those plates for which the residuals have been calculated for several exposures, the mean of the probable errors for the exposures referring to one plate has been taken as the probable residual for that plate.

If we exclude plate 16 the probable divergences are—

$$\text{Probable divergence in } x = 8{\cdot}23 = 1''{\cdot}13$$
$$\text{,,} \qquad \text{,,} \qquad y = 9{\cdot}78 = 1''{\cdot}34$$

It is interesting to notice that the probable divergence in declination is somewhat greater than the probable divergence in R.A.

8. The above, however, do not give the actual probable errors of the star places measured—not only, as has been pointed out, because the meridian places probably are in error, but also because the plate-constants themselves have a probable error, and this will affect the agreement.

I have not been able to obtain the probable errors of the plate constants and of the meridian places directly, but their effect may be allowed for theoretically as follows :—

Consider any residual Δx.

Let ϵ_ξ be the error in ξ due to wrong meridian place, so that

$$\xi + \epsilon_\xi = \text{correct computed coordinate.}$$

Let ε_x be the error of measurement on the plate, so that

$$x + \varepsilon_x = \text{true place of the star on the plate.}$$

Hence accurate difference

$$= \Delta x + \epsilon_\xi - \varepsilon_x.$$

This should be *exactly* fitted by a formula of the type

$$(a + \delta a)x + (b + \delta b)y + c + \delta c,$$

δa, δb, δc being errors of plate constants due to inaccurate meridian places and errors of measurement. Hence

$$\Delta x + \epsilon_\xi - \epsilon_x = ax + by + c + x\delta a + y\delta b + \delta c.$$

Now let ε be the residual O—C, exhibited in the tables

$$\varepsilon = \Delta x - ax - by + c$$
$$\therefore \varepsilon + \epsilon_\xi - \varepsilon_x = x\delta a + y\delta b + \delta c$$
$$\therefore \epsilon_\xi - \epsilon_x = (x\delta a + y\delta b + \delta c - \varepsilon).$$

Square and sum for the n stars measured

$$\Sigma(\epsilon_\xi - \varepsilon_x)^2 = (\delta a)^2\Sigma x^2 + (\delta b)^2\Sigma y^2 + n(\delta c)^2 + \Sigma\varepsilon^2$$
$$+ 2\delta a\delta b\Sigma xy + 2\delta a\delta c\Sigma x + 2\delta b\delta c\Sigma y$$
$$- 2\delta a\Sigma x\varepsilon - 2\delta b\Sigma y\varepsilon - 2\delta c\Sigma\varepsilon$$

Now if, as has been the case for the present reductions, the comparison stars have been chosen symmetrically about the origin of coordinates x, y we have

$$\Sigma xy = 0 \qquad \Sigma x = 0 \qquad \Sigma y = 0$$

or, at all events, these quantities are small compared with Σx^2, Σy^2, &c.

Further, if the solution for the constants has been by least squares

$$\Sigma x\varepsilon = 0 \qquad \Sigma y\varepsilon = 0 \qquad \Sigma\varepsilon = 0$$

In the present case the solution has been by Dyson's approximate method; but as this gives results practically identical with those of the least square solution, the above equations will be very approximately satisfied.

We have then

$$\Sigma(\epsilon_i - \epsilon_x)^2 = (\delta a)^2\Sigma x^2 + (\delta b)^2\Sigma y^2 + n(\delta c)^2 + \Sigma\epsilon^2.$$

Now let $\bar{\epsilon}_i$, $\bar{\epsilon}_x$ be the errors of mean square of the calculated and the measured places respectively, and let $\bar{\epsilon}$ be the mean-square residual for the n stars on any one plate. Then

$$\bar{\epsilon}_i^2 + \bar{\epsilon}_x^2 = (\delta a)^2\frac{\Sigma x^2}{n} + (\delta b)^2\frac{\Sigma y^2}{n} + (\delta c)^2 + \bar{\epsilon}^2$$

provided $\Sigma\epsilon_i\epsilon_x = 0$, which will be the case if the errors in the meridian places and the errors of measurement on the plate are independent.

Sum equations of this kind for a number N of similar sets (*e.g.* exposures) and divide by N. Let $\bar{\epsilon}_a$, $\bar{\epsilon}_b$, $\bar{\epsilon}_c$ be the errors of mean square of a, b, c.

$$\therefore \bar{\epsilon}_a^2 = \frac{\Sigma(\delta a)^2}{N} \quad \bar{\epsilon}_b^2 = \frac{\Sigma(\delta b)^2}{N} \quad \bar{\epsilon}_c^2 = \frac{\Sigma(\delta c)^2}{N}$$

$$\bar{\epsilon}_i^2 + \bar{\epsilon}_x^2 = \bar{\epsilon}_a^2\frac{\Sigma x^2}{n} + \bar{\epsilon}_b^2\frac{\Sigma y^2}{n} + \bar{\epsilon}_c^2 + \bar{\epsilon}^2.$$

We have now to find out the values of $\bar{\epsilon}_a$, $\bar{\epsilon}_b$, $\bar{\epsilon}_c$. Consider a set of differences $\Delta x'$, which satisfy equations of condition

$$ax + by + c = \Delta x'.$$

Suppose that, instead of a, b, c, we have determined constants $a + \delta a$, $b + \delta b$, $c + \delta c$.

We now have residuals

$$x\delta a + y\delta b + \delta c.$$

Now if $\sigma =$ error of mean square of a $\Delta x'$, the probability of any one observation occurring

$$= \text{const.} \times e^{-\frac{(x\delta a + y\delta b + \delta c)^2}{2\sigma^2}}.$$

The probability of the whole n observations is the product

$$\Pi\left(\text{const.} \times e^{-\frac{(x\delta a + y\delta b + \delta c)^2}{2\sigma^2}}\right)$$

$$= \text{const.} \times e^{-\Sigma\frac{(x\delta a + y\delta b + \delta c)^2}{2\sigma^2}}$$

$$= \text{const.} \times e^{-\frac{(\delta a)^2\Sigma x^2}{2\sigma^2} - \frac{(\delta b)^2\Sigma y^2}{2\sigma^2} - (\delta c)^2 \times \frac{n}{2\sigma^2}}$$

the cross-terms going out as before.

This, then, is the probability of the constants $a + \delta a$, $b + \delta b$, $c + \delta c$, coinciding with the given set of observations, *i.e.* the above is the error function for δa, δb, δc.

This gives at once

$$\bar{\epsilon}_a = \frac{\sigma}{\sqrt{\Sigma x^2}} \quad \bar{\epsilon}_b = \frac{\sigma}{\sqrt{\Sigma y^2}} \quad \bar{\epsilon}_c = \frac{\sigma}{\sqrt{n}}.$$

But σ is made up of the errors due both to ξ and to x,

$$\therefore \sigma^2 = \bar{\epsilon}_\xi^2 + \bar{\epsilon}_x^2.$$

So that finally

$$\bar{\epsilon}_a = \sqrt{\frac{\bar{\epsilon}_\xi^2 + \bar{\epsilon}_x^2}{\Sigma x^2}} \quad \epsilon_b = \sqrt{\frac{\epsilon_\xi^2 + \epsilon_x^2}{\Sigma y^2}} \quad \bar{\epsilon}_c = \sqrt{\frac{\bar{\epsilon}_\xi^2 + \bar{\epsilon}_x^2}{n}}.$$

Substituting now in our original equation, we obtain

$$\bar{\epsilon}_\xi^2 + \bar{\epsilon}_x^2 = \left(\bar{\epsilon}_\xi^2 + \bar{\epsilon}_x^2\right)\frac{3}{n} + \bar{\epsilon}^2$$

or

$$\bar{\epsilon}_x^2 = \frac{\bar{\epsilon}^2}{1 - \frac{3}{n}} - \bar{\epsilon}_\xi^2$$

and multiplying by $(\cdot 6745)^2$ to reduce the error of mean square to probable error

$$p_x^2 = \frac{p^2}{1 - \frac{3}{n}} - p_\xi^2$$

where p_x, p, p_ξ are now probable errors.

From this equation we can find the probable error p_ξ of a meridian place, once the mean residual p and the probable error p_x of a measure are known. A similar equation holds for y and η.

Now we shall almost certainly err on the side of exaggeration if we take for our probable error of a measure that deduced from the (direct–reversed) on p. 565. The p.e. of the difference we have seen is about $0''\cdot 7$. Accordingly the p.e. of a measure is probably less than $\frac{1}{\sqrt{2}} \times 0''\cdot 7 = 0''\cdot 5$.

It must, however, be remembered that p_x includes errors due to (1) bad driving, (2) distortion, (3) tilt of the plate, as well as the error due to actual measurement.

I have no means of estimating the exact amount of these errors in the present case. A rough calculation, however, shows that for the outermost stars, which are 2° from the centre, the error due to a tilt of 2′ or 3′ would only amount to 1 or 2 in the last place. This would hardly be sufficient to affect the probable error to any extent.

The distortion, though a cubic term, may be sensible for the

outermost stars. As to the bad driving, its only effect would be to increase the error of actual measurement (which is known), by making the discs elongated, unless indeed the driving was very irregular, which I do not think was the case.

Altogether I believe $p_x = 0''\cdot5$ is a fair value to take, but in any case I hardly think p_x could exceed $0''\cdot7$.

Taking $p_x = 0''\cdot5$ and $p = 1''\cdot23$, *i.e.* the mean of the values for x and y (Plate 16 omitted), we find

$$p_t = 1''\cdot47.$$

This error includes, besides proper motions and actual errors of meridian observations, errors due to cutting off decimals of a second, not only in the places taken from the Catalogue, but also in the reductions. Mr. Dyson tells me that the probable error of the Zone Catalogues is certainly not greater than $0''\cdot7$. This would leave an error of $1''\cdot4$ due to decimal places neglected. This does not seem an impossible value, seeing errors may have accumulated in the complicated reductions.

9. We are now in a position to obtain the probable error of the deduced position of a measured star on the plate whose meridian place is not known.

In this case the error is due to—

(1) Actual error of measurement.

(2) Error due to bad plate constants.

The errors of the meridian places will indirectly affect the deduced position through (2).

Let x' y' be the measured coordinates of such a star. We require to know the probable error of the quantities

$$x' + ax' + by' + c$$
$$y' + dx' + ey' + f$$

Take the first of these. The error is

$$\delta x' + x'\delta a + a\delta x' + y'\delta b + b\delta y' + \delta c.$$

a, b are always very small, compared with x', y' and the terms $a\delta x'$, $b\delta y'$ are quite insensible. In fact, in computing $ax' + by' + c$, we might well cut off the last two places in x' and y' so that for this purpose the latter may be treated as constant. Hence

$$\text{error} = \delta x' + x'\delta a + y'\delta b + \delta c'.$$

Now suppose we have a group of n' such stars symmetrically situated all round, which are measured with a view to their places being obtained.

Squaring and adding, we find if ϵ' be the error of mean square for the place

$$\epsilon'^2 = \bar{\epsilon}_x^2 + (\delta a)^2 \frac{\Sigma x'^2}{n'} + (\delta b)^2 \frac{\Sigma y'^2}{n'} + (\delta c)^2$$

provided the error of measurement $\delta x'$ is independent of the position of the star on the plate, which, on the face of it, appears likely.

Now if $\frac{\Sigma x'^2}{n'} = k'^2 = \frac{\Sigma y'^2}{n'}$, k' represents the "scatter" of the measured stars about the centre of the plate.

From a number of similar sets we have

$$\epsilon'^2 = \bar{\epsilon}_x^2 + \bar{\epsilon}_a^2 \frac{\Sigma x'^2}{n'} + \bar{\epsilon}_b^2 \frac{\Sigma y'^2}{n'} + \bar{\epsilon}_c^2$$

Now remember that

$$\bar{\epsilon}_a = \frac{\sigma}{\sqrt{\Sigma x^2}} = \frac{\sigma}{\sqrt{n}} \sqrt{\frac{n}{\Sigma x^2}} = \frac{\sigma}{\sqrt{n}} \frac{1}{k}$$

and similarly

$$\bar{\epsilon}_b \quad \dots \quad \dots \quad = \frac{\sigma}{\sqrt{n}} \frac{1}{k}$$

$$\bar{\epsilon}_c \quad \dots \quad \dots \quad = \frac{\sigma}{\sqrt{n}}$$

where k measures the "scatter" of the comparison stars about the centre of the plate. Accordingly

$$\epsilon'^2 = \bar{\epsilon}_x^2 + \frac{\sigma^2}{n}\left(1 + \frac{2k'^2}{k^2}\right)$$

$$= \bar{\epsilon}_x^2 + \frac{1}{n}\left(\bar{\epsilon}_x^2 + \bar{\epsilon}_\xi^2\right)\left(1 + \frac{2k'^2}{k^2}\right)$$

or in probable errors

$$p'^2 = p_x^2 + \frac{1}{n}(p_x^2 + p_\xi^2)\left(2\frac{k'^2}{k^2} + 1\right)$$

gives the probable error of a deduced star place.

Two important facts follow at once from the above formula.

(1) The great value of increasing the number n of the comparison stars.

(2) The still greater value of restricting the area over which lie the stars whose places are required to be well inside of the area occupied by the comparison stars, so that k'/k is well under unity.

In our case, taking as before $n = 8$, and supposing the measured stars and the comparison stars to be distributed over the same area, we find, since $k' = k$,

$$p_x = 0''.5 \qquad p_\xi = 1''.47$$
$$p' = 1''.08$$

or the probable error is about $1''$.

If, as should always be done in practice, the measured star is

picked out of a circle of radius about half that of the circle over which the comparison stars are distributed, $k' = \frac{1}{2}k$, and we find

$$p' = 0''\cdot 83$$

or the probable error of a deduced star place is well under a second of arc.

If we take the higher value for p_x, namely $0''\cdot 7$, the calculated error p' (for $k' = \frac{1}{2}k$) $= 0''\cdot 97$, so that the same conclusion holds.

10. The corrections Δx, Δy for the observed positions of the comet for each exposure were then calculated. This gave ξ and η for the comet. The R.A.'s and declinations obtained by solving back the equations are given in the following table :—

TABLE VI.

Places of Comet 1899 *a* (*Swift*).

Exposure.	Date. 1899.	Camb. S.T. of Middle of Exposure. h m s	R.A. h m s	Decl. ° ′ ″
5*a*	May 19	15 49 35	22 23 44·5	45 18 49
5*c*	,,	15 54 48	22 23 42·6	45 19 16
5*d*	,,	15 59 5	22 23 40·6	45 19 32
5*e*	,,	16 2 16½	22 23 39·2	45 19 46
7*a*	,, 23	17 36 50	21 26 20·6	51 56 19
7*b*	,,	17 43 50	21 26 16·0	51 56 27
7*c*	,,	17 50 36	21 26 11·0	51 56 51
10*a*	,, 26	16 37 55	20 27 12·3	55 41 33
10*b*	,,	17 7 2	20 26 43·8	55 42 46
10*c*	,,	17 16 0	20 26 35·8	55 43 9
10*d*	,,	17 23 0	20 26 29 8	55 43 21
11*a*	,, 29	18 4 10	19 12 44·5	57 21 12
11*b*	,,	18 8 45	19 12 38·7	57 21 18
11*c*	,,	18 13 52	19 12 33·9	57 21 8
11*d*	,,	18 22 7	19 12 25·0	57 21 16
14*a*	,, 31	16 12 8	18 24 34·2	56 53 14
14*b*	,,	16 21 32	18 24 25·7	56 53 4
14*c*	,,	16 27 45	18 24 19·1	56 52 46
14*d*	,,	16 34 55	18 24 12·0	56 52 39
16*a*	June 3	18 29 30	17 15 58·5	53 56 53
16*b*	,,	18 37 0	17 15 51·9	53 56 30
17*a*	,, 5	17 40 30	16 41 8·0	51 9 39
17*b*	,,	17 46 30	16 41 3·8	51 9 10
17*c*	,,	17 54 0	16 40 59·4	51 8 48
17*d*	,,	18 5 30	16 40 52·8	51 8 5

The above are the R.A. and declination of the comet, reduced to the epoch 1899·0, and corrected for precession, nutation, and refraction. The aberration correction, however, has to be considered separately. The part of the aberration due to the motion of the Earth has already been implicitly applied, being involved in the plate constants. But in the case of a comet there is another part, due to the motion of the comet.

Accordingly, in order to obtain from the above data the R.A. and Decl. of the comet free from the effects of aberration, the aberration correction for a star must first be applied with its sign *reversed* and the observations then *antedated* in the manner usual for planets and comets.

11. The accuracy of these comet places will not, owing to the difficulty of measuring a diffuse object, which was occasionally so faint that it required an effort to distinguish it, be comparable with the accuracy of determination of star places as given previously.

A rough determination of the probable error can be made by considering that the changes in R.A. and Decl. for the successive exposures on one plate should be proportional to the time elapsed—a condition which is easily seen from the table not to be accurately satisfied.

Taking the difference of the first and last exposures in each case as giving a more correct value of the rate of change, we can calculate the differences between the 1st and 2nd, 2nd and 3rd, 3rd and 4th, these being proportional to the time.

The deviations from these calculated differences will give us a rough measure of the probable error of the difference of two comet places; dividing this by $\sqrt{2}$ we have the probable error of a comet place.

If we take three of the plates which contain four exposures, viz. 11, 14, 17, and treat them in this way, we obtain the following table—

TABLE VII.

		Differences of R.A. Obs.	Cal.	Diff.	Differences of Decl. Obs.	Cal.	Diff.	Differences of Time.
		s	s	s	″	″	″	m s
Pl. 11	$(b-a)$	−5·8	−5·0	·8	+ 6	+ 1	5	4 35
	$(c-b)$	−4·8	−5·5	·7	−10	+ 1	11	5 7
	$(d-c)$	−8·9	−9·0	·1	+ 8	+ 2	6	8 15
Pl. 14	$(b-a)$	−8·5	−9·2	·7	−10	−14	4	9 24
	$(c-b)$	−6·6	−6·0	·6	−18	−10	8	6 13
	$(d-c)$	−7·1	−7·0	·1	− 7	−11	4	7 10
Pl. 17	$(b-a)$	−4·2	−3·6	·6	−29	−23	6	6 0
	$(c-b)$	−4·4	−4·6	·2	−22	−28	6	7 30
	$(d-c)$	−6·6	−7·0	·4	−43	−43	0	11 30

Hence

Mean diff. in R.A.	$= 0^s{\cdot}47$
„ „ Decl.	$= 5''{\cdot}6$
Probable error in R.A.	$= 0^s{\cdot}33$
„ „ Decl.	$= 4''{\cdot}0$

To get the probable error in angle in the direction of ξ we have to multiply $0^s{\cdot}33$ ($= 5''{\cdot}0$) by sin (mean N.P.D. for plates 11, 14, 17), *i.e.* sin $35° = {\cdot}57$.

This gives

p.e. in ξ in arc	$= 2''{\cdot}9$
p.e. in η „	$= 4''{\cdot}0$

We may take it therefore that the probable error of any one comet place is under $5''$.

12. The results of these reductions show that photographs taken with an ordinary portrait lens are capable, when measured and reduced, of giving star places to about $1''$. In the case of the comet the accuracy is less than this, the probable error being under $5''$. Such an instrument appears therefore to be well adapted for work not requiring a very high degree of precision.

Incidentally it appears that in reducing such plates it is sufficient, in general, to use the same set of plate constants a, b, d, e for all the exposures on a plate.

The value of increasing the number of the comparison stars, and of taking the stars whose place is to be deduced well *inside* the comparison stars, appears from the consideration of the probable errors.

It is also hoped that the comet places may be of value for comparison with the calculated orbit. I can only express my regret that, from the causes mentioned at the beginning of the paper, these data could not be made available earlier.

In conclusion I wish to thank Sir Robert Ball for kindly allowing me to carry out this work at the Cambridge Observatory, and Professor Karl Pearson, of University College, London, for letting me use the Brunsviga calculating machine belonging to his department, which has proved a great help in the reductions.

I also wish to thank very heartily Mr. Hinks, of the Cambridge Observatory, for the exceedingly valuable assistance and advice, both as regards the observations and the reductions, with which he has always been ready to help me.

Note added 1902 *July* 5.

Since writing the above I have been able to deduce directly the error p_x from the final results. The conclusions as to the numerical value of the probable error p' of star places deduced have been somewhat modified.

If we consider the *differences* of O—C for various exposures, I find the probable error of such a difference for two exposures on one plate to be, both for x and for y,

$$p_{\delta o - \delta c} = 1''.00.$$

Now, if we suppose the various exposures reduced to the mean of the stars as origin, we have an equation of condition

$$ax + by + c = \delta\xi - \delta x + \Delta_1 x,$$

$\Delta_1 x$ being the *correct* difference if there were no errors.

The equations giving the constants are :

$$\begin{aligned} a\Sigma x^2 &= \Sigma x\delta\xi - \Sigma x\delta x + \Sigma x\Delta_1 x \\ b\Sigma y^2 &= \Sigma y\delta\xi - \Sigma y\delta x + \Sigma y\Delta_1 x \\ cn &= \Sigma\ \delta\xi - \Sigma\ \delta x + \Sigma\ \Delta_1 x. \end{aligned}$$

We may note in passing that this shows that the errors $\delta\xi - \delta x$ cannot be perfectly random, but must be correlated with the coordinates if an error in the plate constants a, b, c is to exist. For a large number of similar sets, however, the distribution of $\delta\xi - \delta x$ is random, although any *individual* set deviates from the random type.

For another exposure the same equations are :

$$\begin{aligned} a'\Sigma x^2 &= \Sigma x\delta\xi - \Sigma x\delta x' + \Sigma x\Delta_1 x \\ b'\Sigma y^2 &= \Sigma y\delta\xi - \Sigma y\delta x' + \Sigma y\Delta_1 x \\ c'n &= \Sigma\ \delta\xi - \Sigma\ \delta x' + \Sigma\Delta_1 x. \end{aligned}$$

Subtract, and we have :

$$\begin{aligned} (a-a')\Sigma x^2 &= -\Sigma x(\delta x - \delta x') \\ (b-b')\Sigma y^2 &= -\Sigma y(\delta x - \delta x') \\ (c-c')\ n &= -\Sigma\ (\delta x - \delta x'). \end{aligned}$$

The $\delta\xi$'s being the same for both exposures.

Now any difference

$$\begin{aligned} &\delta\ (O-C) \\ &= \delta x - \delta x' + (a-a')\ x + (b-b')y + (c-c'). \end{aligned}$$

Square and sum for the n comparison stars :

$$\begin{aligned} &\Sigma\ (\delta O - \delta C)^2 \\ &= \Sigma\ (\delta x - \delta x')^2 + 2(a-a')\ \Sigma x(\delta x - \delta x') \\ &\qquad + 2(b-b')\ \Sigma y(\delta x - \delta x') \\ &\qquad + 2(c-c')\ \Sigma\ (\delta x - \delta x') \\ &\qquad + (a-a')^2\Sigma x^2 \\ &\qquad + (b-b')^2\Sigma y^2 \\ &\qquad + (c-c')^2 n \end{aligned}$$

$$= \Sigma(\delta x - \delta x')^2 - \frac{1}{\Sigma x^2}[\Sigma x(\delta x - \delta x')]^2 - \frac{1}{\Sigma y^2}[\Sigma y(\delta x - \delta x')]^2 - \frac{1}{n}[\Sigma(\delta x - \delta x')]^2$$

Sum this again for a large number N of similar sets, then it is easy to show that $p_{x-x'}$, $p_{\delta o - \delta c}$ being probable errors

$$p^2_{x-x'}\left(1-\frac{3}{n}\right) = p^2_{\delta o - \delta c}$$

whence

$$p^2_x = \tfrac{1}{2}p^2_{x-x'} = \tfrac{1}{2}1''\cdot00 \times \tfrac{8}{5} = ''\cdot8$$

$$\therefore p_x = ''\cdot9 \text{ nearly.}$$

This shows that my previous estimate was too low, and errors due to bad driving, &c., must have been more important than I thought.

This gives $p_t = 1''\cdot26$.

Finally the error of a deduced star place ($k' = \frac{1}{2}k$) $p' = 1''\cdot12$.

This is somewhat larger than the previous result. The error of the star place is accordingly slightly above, instead of slightly under, a second of arc.

The magnitude of p_p, as stated in the paper, is chiefly to be attributed to the accumulated error in the reductions. This arose through the use of an auxiliary angle, which was computed only to the nearest second.

A Dark Reticle. By Chas. S. Howe, Ph.D., Professor of Astronomy, Case School of Applied Science, Cleveland, Ohio (U.S.A.).

About a year ago it occurred to me that dark reticles might have some advantage over the ordinary reticles for transit circles and almucantars. During the past winter some experiments have been made to test their value. These reticles have been made of thin glass covered with some dark substance, and the lines have been cut through this substance to the surface of the glass. A number of experiments were made to find the best material to form the dark layer; it was finally decided to silver the glass. This has proved very satisfactory: fine, sharp lines can be cut in the silver, and if glass with a perfectly smooth surface has been selected, the star can be seen without any difficulty. The silver covers the centre of the glass only, so that the star can be seen when it comes into the field and until it reaches

the reticle ; then it disappears, but as it reaches each wire there is a flash of light and the chronograph key is tapped. For stars near the pole the light does not flash across the line, but lights it up gradually ; the star finally comes into view, remains for an instant—hardly more than time enough to tap the key—and then slowly fades away. Some of the theoretical advantages of the new reticle are :—

1st. The probable error of tapping the key upon the flash would be less than upon the bisection of a star with a wire. With an ordinary reticle the eye and the mind of the observer are under a constant strain to determine when a star is bisected, or to estimate when it will be bisected. With the dark reticle the observer looks into a dark eyepiece, sees nothing, and does not try to see anything until the flash comes, when he strikes the key. Except in case of stars much fainter than are ordinarily observed, there is no difficulty in seeing the flash, and there is no strain upon the eye or upon the attention. It would seem, therefore, that the probable error of tapping the chronograph key would be less than in the old method.

2nd. The personal equation would be less for the reasons given above.

3rd. That part of the personal equation depending upon bright field or bright wires would be eliminated, because all stars would be observed with a dark field.

4th. Fainter stars could be observed, because no light would be lost from the bright field or bright wires.

After the observations mentioned in this article had been made it was found that a London firm of instrument makers was advertising in its catalogue a "flashing transit eyepiece" which seemed to be similar to the dark reticle described here. I have not, however, been able to find any record of observations made with it.

In order to test the probable error of tapping the key when the dark reticle was used, the method described in Chauvenet's *Practical Astronomy*, vol. ii. p. 194, was followed. The observations were made with the large almucantar of the Case Observatory.

Let I = the observed interval between two wires for a star of declination δ.

Computed i = I reduced to the angular distance between the same wires.

True i = true angular distance between the same wires.

r = probable error of the angular distance between two wires.

ϵ = probable error of tapping the key on one wire.

Then $r = \cdot 6745\sqrt{\frac{[vv]}{m-1}}$, and $\epsilon = \cdot 6745\sqrt{\frac{[vv]}{2(m-1)}}$.

46 *Leonis Minoris* observed 1902 March 13 gave the following results :—

I	Computed i	True i	V.
s	s	s	
1·84	1·34	1·38	−·04
1·81	1·32	1·35	−·03
1·90	1·38	1·34	+·04
1·90	1·38	1·36	+·02
1·77	1·29	1·38	−·09
1·89	1·38	1·36	+·02
1·77	1·29	1·34	−·05
1·94	1·41	1·35	+·06

Thirty-five stars gave $[vv] = 1{\cdot}6427$, $m = 280$, and $\epsilon = {}^{s}{\cdot}037$. Twenty-two of these stars were time stars for which $\epsilon = {\cdot}037$; the other thirteen were north of declination 70° and $\epsilon = {\cdot}036$.

Thirty-five stars observed with the ordinary reticle gave $\epsilon = {\cdot}037$. Twenty-seven of these were time stars, and gave $\epsilon = {\cdot}036$; the remaining eight were north of 70° declination, and gave $\epsilon = {\cdot}038$.

So far as the probable error of observation is concerned, there is then no difference between the two reticles. This probable error is undoubtedly made up of several components, but as the subject of this investigation was the comparison of the two reticles it is not necessary to separate them. No observations have yet been made to determine difference of personal equation. The greatest advantage of the dark reticle would seem to be in observations of *very* faint stars, for they would be observed in the same way as the other stars, whereas now they are observed with bright wires in a dark field.

Case Observatory, Cleveland, O. (U.S.A.)

Observation of the Total Eclipse of the Moon, 1902 April 22, at Perth Observatory, Western Australia.

(*Communicated by W. Ernest Cooke, M.A., Government Astronomer.*)

The total eclipse of the Moon was observed here by Mr. Johns with a 10-inch refractor on 1902 April 22. The following phases were noted :—

	h	m	s	
Beginning of totality	6	10	47	G.M.T.
End ,, ...	7	35	14	,,
Last contact with shadow ...	8	47	34	,,

It was cloudy for first contact, and there were passing clouds during last, but at the times of the other observations it was

quite clear. Colour copper, very dark in centre, but bright near edges. Limb easily seen through telescope. No occultations.

Perth Observatory, W.A.:
1902 *April* 29.

Observations of Jupiter made at Mr. E. Crossley's Observatory, Bermerside, Halifax, during the months of July, August, and September, 1901. By Joseph Gledhill.

The following observations of the bands, spots, &c. on the surface of *Jupiter* were made with the 9-inch Cooke refractor (photo-visual). Owing to the considerable south declination of the planet and the unsettled weather it was impossible on any occasion to obtain a really fine view of the details of the markings on the disc. The highest power used was 240, but 150 was found to be most generally useful.

For shortness the dark bands and bright zones are designated as follows :—

a the S. temperate band.
b the S. equatorial belt.
c the N. equatorial belt.
d the N. temperate band.
e the N.N. temperate band.
f the S. tropical zone.
g the equatorial zone.
h the N. tropical zone.
λ is the longitude of the central meridian System II.

The one salient feature of the disc during the whole of the opposition was the dark broad double band just S. of the equator (S. equatorial belt). There was never any bright space distinctly seen between the components of this fine belt ; but, as in past years, the separation was best seen a little to the west of the preceding shoulder.

The red spot was not seen, but a faint grey wisp was once or twice glimpsed resting on the highest point of the ***f*** shoulder and bending south and westwards : this was probably the eastern end of the red spot or a marking connecting the eastern end with the ***f*** shoulder.

No warm colour and no distinct detail were seen in the equatorial zone ; indeed, there seemed to be a great sameness of tint or brightness over the whole disc ; no zone was notably brighter than any other away from the polar regions.

The N. component of ***b*** (S. equatorial belt) was usually darker than the S. one, and had many dark spots on it which projected a little into the bright central zone.

July 3, 10^h, $\lambda = 290°$. A dark spot on the N. component of ***b*** central about $11\frac{1}{2}^h$ ($\lambda = 54°$). ***a*** and ***c*** faint grey bands. Rough measures : the double dark band ***b*** $3''{\cdot}8$ in width ; the central bright zone ***g***, $3''.8$ wide ; ***a*** $1''{\cdot}4$; ***f*** $2''{\cdot}3$; ***c*** $1''{\cdot}4$; ***h*** $3''{\cdot}2$.

July 13, $9\frac{1}{2}^h$, $\lambda = 336°$. ***a*** as dark or darker than ***c***; ***b***, as usual, the darkest band and the broadest; the N. component of ***b*** much darker than the S.; ***c*** faint and narrow; ***d*** well marked and as dark as ***c***; ***e*** faint and broader than ***d***.

July 15, 9^h, $\lambda = 259°$. ***a***, ***c***, ***d*** faint; the western half of ***a*** is darker than the eastern half. At 10^h, $\lambda = 295°$: zone ***f*** much narrower than zone ***h***; ***h*** is nearly as wide as ***g***; zone ***h*** is the brightest; the N. component of ***b*** is much broken up and is darker than the S. component.

July 17, 10^h, $\lambda = 236°$. A grey cloud or large spot lies on the S. edge of the great double S. equatorial belt ***b***: it projects into the S. tropical zone until it nearly touches the N. edge of the S. temperate band ***a***.

July 19, 10^h, $\lambda = 176°$. The N. component of ***b*** is much broken up; ***a*** and ***c*** are faint; ***d*** is broader than ***c***; ***e*** (the N. temperate band) is narrow; a faint band is seen to the S. of ***a***.

Aug. 15, 8^h, $\lambda = 182°$. The dusky cloud or spot on the S. edge of ***b*** is seen.

Aug. 16, 8^h, $\lambda = 353°$. A bright gap or break in the S. component of ***b*** is seen: it was central about $7^h\ 53^m$. ***a*** is broader than ***c*** or ***d***; ***d*** is the faintest band.

Aug. 18. About $8^h\ 45^m$ a dark piece of (or dark spot on) the N. component of ***b*** was central; a similar one precedes it. They are not rounded but rectangular forms. Band ***a*** is nearer to ***b*** than ***b*** is to ***c***. At 9^h, $\lambda = 329°$; a bright gap or break in the N. component of ***b*** was seen: it is close behind the dark spot and on the central meridian.

Aug. 19, 10^h, $\lambda = 166°$. A dark spot on the N. component of ***b*** seen on central meridian about $10^h\ 18^m$. Bands ***c*** and ***d*** darker than ***a***; ***d*** is broader than ***a*** or ***c***.

Aug. 20. A dark spot on ***b*** was central about $7^h\ 42^m$. A few rough measures were made: S. pole to middle of double band ***b*** 16″·6; N. pole to same 23″·3; the sum gives the polar diameter, 39″·9. [The computed value is 41″·33.] Width of double band ***b*** 3″·4; N. edge of ***b*** to S. edge of ***c*** 3″·1. A dark spot on ***b*** was central about $7^h\ 35^m$; a gap in ***b*** central about $8^h\ 43^m$.

August 22, 8^h. Rough measures: middle of band ***b*** to S. pole 18″·3; S. pole to S. edge of ***b*** 15″·6; width of ***b*** 3″·4; S. pole to N. edge of ***b*** 18″·3; middle of ***b*** to ***c*** 6″·1; ***c*** to ***d*** 6″·1; ***d*** to N. pole 11″·5; ***a*** to S. pole 12″·2; ***a*** to middle of ***b*** 5″·4; polar diameter 41″·5; computed polar diameter from Mr. Crommelin's ephemeris 41″·1. A faint cloudy form lay on the S. edge of ***b*** and extended southwards quite or nearly across zone ***f***: it was central about $9^h\ 17^m$. At 8^h band ***a*** was fainter than ***c*** or ***d***, and ***d*** as dark and broader than ***c***.

August 24, $7\frac{1}{2}^h$. ***a*** very faint; ***c*** nearly as dark as ***b***, but of course, as always this opposition, very much narrower; ***d*** much broader than ***a*** or ***c***. N. of ***d*** comes a bright zone as wide as ***d*** is broad. A few measures: S. pole to middle of ***b*** 16″·9;

middle of ***b*** to ***c*** 6″·8 ; width of ***b*** 4″·5 : N. edge of ***b*** to ***c*** 3″·7 ; ***c*** to N. pole 18″·3 ; ***c*** to S. pole 32″·3 ; central zone ***g*** 4″·5 ; polar diameter 42″·6 [the ephemeris value 40″·9] ; ***a*** very faint from $7\frac{1}{2}^h$ to 9^h. A dark spot on ***b*** (the N. component) was central about $8^h\ 40^m$. About 9^h a few measures were made ; middle of ***b*** to S. pole 18″·4 ; middle of ***b*** to N. pole 23″·6 ; width of ***b*** 4″·6 ; S. edge of ***d*** to N. pole 10″·5 ; N. edge of ***d*** to N. pole 8″·1 ; width of ***d*** 2″·4 ; S. pole to ***a*** 10″·5 ; middle of ***b*** to ***c*** 6″·1 ; ***c*** to ***d*** 4″·7 ; S. edge of ***d*** to N. pole 11″·5 ; width of ***b*** 4″·5 ; S. edge of ***b*** to S. pole 15″·6 ; N. edge of ***b*** to S. pole 20″·3 ; width of ***b*** 4″·7. A dark spot on the N. component of ***b*** was central about $9^h\ 18^m$; another follows it closely. The bright zone ***h*** is a little wider than bright zone ***g***.

August 27, 7^h, $\lambda = 169°$. ***a*** is faint ; ***d*** is broader than ***c*** ; there is a bright narrow zone N. of band ***d***. A dark spot on the N. component of ***b*** is now near the central meridian. A narrow bright zone lies immediately S. of ***a***. The region N. of ***c*** up to the pole is brighter than the region about the S. pole. The grey spot on ***b*** above named was central about $8^h\ 22^m$: it is faint and diffuse ; its length is about 4″, and the height perhaps about the same.

September 4, 8^h, $\lambda = 327°$. ***a*** is as well seen as ***c*** and ***d***.

September 5, 7^h, $\lambda = 81°$. The ***f*** shoulder is a little W. of the central meridian. ***a*** is faint ; ***c*** is narrow but darker than ***a*** ; ***d*** is broader and darker than ***c***.

September 10, 7^h, $\lambda = 112°$. ***a*** faint ; ***d*** broader than ***c***. $7^h\ 10^m$ to $7^h\ 15^m$ one (or two ?) dark spots on band ***b*** (N. component) very near or on the meridian ; and the ***f*** shoulder is near the ***p*** limb.

September 11, 7^h, $\lambda = 262°$. ***a*** is fainter than ***c*** or ***d***.

September 15, 8^h, $\lambda = 179°$. The grey spot on the S. edge of ***b*** is seen ; probably on the meridian about $8^h\ 15^m$; planet low and motion very great.

September 18, 6^h, $\lambda = 197°$. ***a*** faint ; ***c*** broad and well seen ; ***d*** broad and less dark than ***c***. The grey spot on ***b*** central about $6^h\ 20^m$.

September 20, 8^h, $\lambda = 209°$. The grey spot on ***b*** central about 8^h.

October 17, 5^h, $\lambda = 193°$. The grey spot on ***b*** on the central meridian about 5^h ? Violent motion ; Sun just set ; ***a*** faint ; ***c*** darker ; ***d*** still darker and broader than ***a*** or ***c***.

Collecting the transits of the grey spot on the S. edge of ***b*** and lying in and across zone ***f*** we have :

1901.	d	h	m	°	1901.	d	h	m	°
July	17	10	15	245	Sept.	15	8	15	188?
Aug.	15	8	38	225		18	6	20	209?
	20	7	42	223		20	8	0	209?
	22	9	17	221	Oct.	17	5	0	193?
	27	8	22	219					

Further Observations of the New Star in Perseus made at the Radcliffe Observatory, Oxford.

(*Communicated by Arthur A. Rambaut, M.A., Sc.D., F.R.S., Radcliffe Observer.*)

This paper is in continuation of the notes on the same subject published in the *Monthly Notices* for March, April, May, June, and November 1901.

No periodical fluctuation of brightness has been noticed, but a gradual diminution at the rate of about 0·01 mag. per diem, as remarked in the last paper (*Monthly Notices*, lxii. No. 1), has been maintained. Accordingly no attempt has been made to keep a continuous watch upon the star, and the observations have been made at comparatively long intervals.

The Nova continues to become more bluish. In the last paper it was pointed out that the star appeared for the most part colourless. From the observers' notes on colour in the present paper it will be seen that a bluish tint has for the most part prevailed.

The faintness of the object, its low altitude, and the increased twilight will probably prevent further observations until the autumn.

The following instruments were employed as indicated in the third column of Table II.

Barclay	10-inch equatorial,	power 90.
	2·7-inch finder	„ 13.
Heliometer	1·8 inch finder	„ 19.

TABLE I.

List of Stars used for Comparison with Nova Persei.

Ref. No.	Name of Star.	Adopted Tabular Magnitude.	Authority for Magnitude.
54	Arg. Z. +44°, 734	6·23	Radcliffe estimations on Harvard Scale.
58	+43, 730	6·57	„ „ „ „ „
61	+41, 631	6·00	Harvard Photom. D.M.
62	+41, 638	6·16	„ „ „
63	+42, 736	7·00	Adopted provisionally.
64	+43, 720	7·25	„ „
65	+43, 732	7·25	Harvard Photom. D.M.
67	+44, 714	7·37	„ „ „
70	+44, 732	7·32	„ „ „
71	+42, 772	7·52	„ „ „
72	+43, 766	8·0	Argelander D.M.
73	+44, 717	8·5	„ „

Ref. No.	Name of Star.	Adopted Tabular Magnitude.	Authority for Magnitude.
74	Arg. Z. +44°, 742	7·76	Harvard Photom. D.M.
75	+43, 728	8·4	Argelander D.M.
76	+43, 729	8·7	„ „
77	+43, 739	9·0	„ „
78	+42, 776	7·8	„ „
79	+42, 767	9·5	„ „
80	+42, 768	8·9	„ „
81	+43, 744	8·6	„ „
82	+43, 746	9·1	„ „
83	+43, 751	9·0	„ „
84	+43, 749	9·0	„ „

TABLE II.

Means of Estimations of Magnitude of Nova Persei.

G.M.T. 1901.	h	m	Observer.	Aperture of Telescope. Inch.	Reference Stars.	Mean Mag.	Adopted Mag. for the Night.
Nov. 15	7	30	R.	1·8	64, 65	7·17	7·17
21	8	30	C.	2·7	65, 64, 70, 67	7·37	7·24
	9	20	W.	2·7	65, 64, 54	7·21	
	9	20	W.	10·0	65, 64, 58, 62-63	7 07	
28	5	45	W.	2·7	65, 64	7·25	7·20
	5	45	W.	10·0	65, 64, 58, 63, 62, 61	6·90	
	5	45	R.	2·7	64, 65	7·20	
	7	0	C.	2·7	64, 67, 65, 70	7·37	
	7	0	C.	10·0	65, 70	7·28	
Dec. 2	8	35	R.	2·7	65, 64	7·30	7·35
	8	55	R.	10·0	65, 64	7 40	
4	8	30	W.	2·7	65, 64, 58, 70	7·24	7 32
	8	35	W.	10·0	65, 64, 54, 70	7·16	
	8	45	R.	2·7	65, 64, 58, 70, 67	7·42	
	8	50	R.	10·0	65, 64	7·50	
1902. Jan. 4	9	45	C.	10·0	65, 71, 72, 70	7·52	7·52
28	10	8	C.	10·0	71, 72, 73, 74	7·97	7·97

G.M.T.	Observer.	Aperture of Telescope.	Reference Stars.	Mean Mag.	Adopted Mag for the Night.
1902. h m		Inch.			
Feb. 10 11 30	R.	2·7	71, 75, 73, 72, 77	8·08	8·27
11 30	R.	10·0	71, 76, 73, 72, 77	8·46	
Mar. 12 10 30	R.	10·0	77, 72, 73, 71, 78, 76 80, 79, 81, 82, 83	8·66	8·66
29 10 53	C.	10·0	77, 81, 82, 83, 84, 76	8·80	8·80

Observers' Notes on the Estimation of Magnitude.

1901.
Nov. 15. The Nova, by averted vision, appeared much brighter than other stars of the same magnitude. This peculiarity caused a difficulty in estimating magnitudes. It was not easy to get rid of the bias formed by the first view of the Nova before placing it and the comparison stars successively in the centre of the field. Sky foggy.

Nov. 21. With the 10-inch, power 90, Nova is ½ mag. fainter than No. 58. Bright moonlight (C.). The image of Nova in the 10-inch is sharp and in good focus with those of other stars. No nebulosity, but the sky is moonlit (W.).

Dec. 4. In comparing Nova with Nos. 65 and 64 in the 10-inch, using power 90, I found it was necessary for the best definition to focus each star separately when in centre of field. The margin of the image of Nova seemed narrower to-night than on November 28. No. 64 is duller than No. 65, but I thought its image a trifle larger than No. 65. Sky is clear, but there is some ground-fog, and horizon stars are nearly obliterated (W.). Sky is somewhat foggy, but the field around No. 64 seems blacker than that around the Nova (R.).

1902.
Jan. 28. Observations much interrupted by cloud.

Feb. 10. Field of 2·7-inch "Finder" not clear; object-glass fogged with condensation.

Mar. 12. Nova in the 2·7-inch "Finder" is brighter than No. 77, and fainter than No. 72.

Mar. 29. Passing clouds very troublesome.

Observers' Remarks on Colour of Nova and Comparison Stars.

1901.
Nov. 21. Nova bluish-white in the 10-inch (C.). With the 10-inch, No. 64 reddish; No. 58 very red; a suspicion of red fringe to Nova (W.).

Nov. 28. No. 64 is red in the 2·7-inch. With the 10-inch No. 64 is light red; No. 58 is strongly tinged with red; and the spurious disc of the image of Nova is pearly white with fainter soft white margin (W.). Nova is bluish-white in the 10-inch, with powers 90, 180, and 250 (C.).

Dec. 2. Nova white and No. 64 orange-red in the 10-inch.

Dec. 4. In the 10-inch Nova is opaque-white with a bluish tinge (very slight tint); No. 65 is very light yellow tint and No. 64 a decidedly reddish tint (W.).

1902.
Jan. 4. Nova white in 10-inch. Nos. 70 and 72 deep orange.

Jan. 28. Nos. 72 and 74 orange in the 10-inch. Nova white.

Feb. 10. In the 10-inch No. 72 orange-red and Nova dull.

Mar. 12. Nova is dull and bluish in the 10-inch; No. 72 is orange-red.

Mar. 29. Nova is bluish and dull in the 10-inch.

The observers were :—Mr. Wickham, indicated by W.
Mr. Robinson, „ R.
Mr. McClellan, „ C.

Radcliffe Observatory, Oxford :
1902 *June* 10.

Further Observations of the New Star in Persus (5).
By A. Stanley Williams.

My early observations of this star up to 1901 June 10 have already been communicated to the Society.* The present paper contains the continuation up to the present time. The photometric magnitudes of a number of the fainter stars in the neighbourhood of the Nova have recently been published by Messrs. G. Müller and P. Kempf in the *Astronomische Nachrichten*, No. 3779, and these magnitudes have been adopted for the comparison stars in reducing the observations. The following is a list of the comparison stars used, with the magnitudes according to Müller and Kempf. The first column contains the designation of the star employed in the present observations.

Comparison Stars.

Designation.	Name.	Magnitude.
(32)	32 Persei	5·18
(36)	36 Persei	5·54
(30)	30 Persei	5·65
b	B.D. + 43°·730	6·57
a	„ + 44°·734	6·61
e	„ + 43°·732	7·41
g	„ + 43°·729	8·70
h	„ + 43°·739	9·11

The above magnitudes have been used in reducing all the telescopic observations. But for those made with the opera-glass the magnitudes of *a* and *b* have been assumed to be 6·25 and 6·50. Both these stars are accompanied by bright companions, and the presence of the latter evidently affected the brightness as observed with the opera glass. The increase of brightness indicated by the above values is less than what should result from combining the light of the component stars of the two groups, but their adoption renders the opera-glass observations comparable with the telescopic.

According to the photometric observations *b* should be

* See *Monthly Notices*, vol. lxi. pp. 337, 396, 480 and 550.

slightly brighter than *a*, but visually the latter was decidedly brighter than the former. This difference is no doubt due to the orange-red colour of *b*,* and was greater with the $2\frac{3}{4}$-inch refractor than with the $6\frac{1}{2}$-inch reflector. All the observations have been reduced with a step value of 0·07 mag. In the last column of the following table, $6\frac{1}{2} = 6\frac{1}{2}$-inch reflector, p. 50; $2\frac{3}{4} = 2\frac{3}{4}$-inch refractor, p. 35; $1\frac{1}{2} =$ the $1\frac{1}{2}$-inch finder of the reflector, p. 12; and Op. = opera-glass.

Observations of Brightness of the Nova.

Date. 1901.	G.M.T. h m	Observations.	Magnitude.	Inst.
June 14	13 20	(36) 9 N 6 *a*	6·18	$2\frac{3}{4}$
14	14 5	(36) 8 N 7 *a*	6·11	,,
14	14 10	(36) 8 N 8 *a*	6·07	,,
17	12 40	(36) 12 N 3 *a*	6·39	,,
17	13 15	(36) 12 N 3 *a*, N 8 *b*	6·26	,,
18	13 0	(36) 10 N 5 *a*	6·25	,,
18	13 25	(36) 10 N 5 *a*, (30) 10 N	6·28	,,
23	12 40	*a* = N 7 *b*	6·34	,,
24	12 30	(36) = N 12 *a*, (30) = N, (32) 5 N	5·62	,,
24	13 15	(32) 4 N 15 *a*, N 2 (36), N 2 (30)	5·46	,,
24	13 52	(32) 2 N 3 (36), N 3 (30)	5·36	,,
26	12 40	(36) 8 N 5 *a*	6·18	,,
26	13 10	(36) 9 N 5 *a*, (30) 10 N	6·26	,,
27	12 20	(36) 9 N 6 *a*, (30) 9 N	6·21	,,
27	12 53	(36) 6 N 8 *a*, (30) 8 N	6·07	,,
July 28	12 13	(36) 12 N 2 *a*, N 10 *b*	6·24	,,
28	12 25	(36) 9 N 5 *a*	6·21	,,
28	13 55	(36) 9 N 6 *a*	6·18	,,
29	12 50	(36) 10 N 6 *a*, N 10 *b*	6·10	,,
29	13 50	(36) 10 N 4 *a*	6·28	,,
Aug. 3	11 50	(36) 10 N 5 *a*	6·25	,,
3	13 5	(36) 11 N 4 *a*, N 10 *b*	6·17	,,
3	14 55	(36) 8 N 7 *a*	6·11	,,
4	12 0	(36) 8 N 5 *a*	6·18	,,
6	11 15	(36) 11 N 4 *a*, (30) 10 N	6·33	,,
6	14 0	(36) 12 N 3 *a*, N 8 *b*	6·26	,,
8	11 30	(36) 8 N 7 *a*, (30) 8 N	6·14	,,
8	15 0	N = *a*, N = *b*	6·59	$6\frac{1}{2}$

* Comparison with the results of other observers seems to show that red stars appear distinctly fainter to my eye than they do to those of most observers.

Date. 1901.	G.M.T. h m	Observations.	Magnitude.	Inst.
Aug. 8	15 0	N 2 *a*, N 10 *b*	6·17	$1\frac{1}{2}$
8	15 0	N 2 *a*, N 10 *b*	6·17	$2\frac{3}{4}$
9	10 55	(36) 8 N 7 *a*, (30) 10 N 15 *b*	6·02	,,
10	12 50	(36) 13 N = *a*, N 8 *b*	6·36	,,
10	15 0	*a* = N 5 *b*	6·41	,,
10	15 0	*a* 1 N	6·32	Op.
11	14 20	(36) 10 N 3 *a*, N 10 *b*	6·17	$2\frac{3}{4}$
11	14 20	*a* 1 N	6·32	Op.
12	12 5	N 1 *a*, N 8 *b*	6·27	$2\frac{3}{4}$
15	11 0	*a* = N 3 *b*, N 10 *c*	6·56	,,
15	13 5	*a* 3 N	6·46	Op.
15	13 15	*a* = N 3 *b*	6·48	$2\frac{3}{4}$
16	11 20	*a* 3 N	6·46	Op.
16	11 30	*a* = N 1 *b*, N 10 *c*	6·61	$2\frac{3}{4}$
16	13 47	*a* 3 N 3 *b*	6·37	Op.
18	10 55	*a* = N 5 *b*, N 12 *c*	6·47	$2\frac{3}{4}$
18	13 15	*a* 3 N 2 *b*	6·41	Op.
18	14 8	*a* 2 N 2 *b*, N 10 *c*	6·63	$2\frac{3}{4}$
19	11 15	N 1 *a*, N 5 *b*, N 12 *c*	6·44	,,
19	14 8	N 2 *a*, N 7 *b*, N 12 *c*	6·37	,,
19	14 8	*a* 2 N 2 *b*	6·37	Op.
20	11 0	*a* 3 N 3 *b*	6·37	,,
20	11 20	*a* = N 4 *b*, N 12 *c*	6·49	$2\frac{3}{4}$
20	14 0	*a* = N 4 *b*, N 12 *c*	6·49	,,
21	10 5	*a* 4 N 1 *b*	6·48	Op.
21	11 5	*a* 2 N 2 *b*, N 10 *c*	6·63	$2\frac{3}{4}$
21	14 10	*a* 4 N 1 *b*	6·48	Op.
22	10 45	*a* = N 5 *b*	6·20	,,
22	11 54	*a* = N 3 *b*, N 12 *c*	6 51	$2\frac{3}{4}$
22	13 30	*a* 3 N 2 *b*	6·41	Op.
22	14 45	*a* 3 N 2 *b*	6·41	,,
23	11 10	*a* 2 N 2 *b*, N 10 *c*	6·63	$2\frac{3}{4}$
23	14 10	*a* 2 N 2 *b*	6·37	Op.
24	?	*a* 5 N = *b*	6·55	,,
24	13 35	*a* 3 N = *b*, N 12 *c*	6·65	$2\frac{3}{4}$
26	10 47	*a* 4 N = *b*, N 10 *c*	6·72	,,
26	14 47	*a* 2·5 N 3·5 *b*	6·34	Op.
26	14 47	*a* 3 N = *b*	6·69	$6\frac{1}{2}$
27	13 55	*a* 3 N 1 *b*, N 12 *c*	6·63	$2\frac{3}{4}$

Date. 1901.	G.M.T. h m	Observations.	Magnitude.	Inst.
Aug. 30	16 5	*a* 6 N, *b* 3 N 10 *c*	6·84	$6\frac{1}{2}$
Sept. 1	10 45	*a* 3 N = *b*, N 12 *c*	6·65	$2\frac{3}{4}$
1	16 13	*a* 5 N, *b* 3 N 6 *c*	6·91	$6\frac{1}{2}$
3	8 30	*a* 5 N = *b*	6·55	Op.
3	10 35	*a* 3 N = *b*, N 12 *c*	6·65	$2\frac{3}{4}$
4	8 48	*a* 5 N = *b*	6·55	Op.
4	10 5	*a* 4 N, *b* 1 N 10 *c*	6·75	$2\frac{3}{4}$
5	9 12	*a* 4 N 1 *b*	6·48	Op.
5	10 8	N 2 *a*, N 5 *b*	6·34	$2\frac{3}{4}$
5	12 50	N 3 *a*, N 6 *b*	6·27	,,
5	14 40	*a* 2 N = *b*, N 8 *c*	6·72	$6\frac{1}{2}$
7	9 15	*a* 4 N 1 *b*	6·48	Op.
10	10 0	*a* 4 N 2 *b*	6·44	,,
11	15 0	*a* 5 N = *b*	6·55	,,
14	16 0	*a* 4 N 1 *b*	6·48	,,
17	10 30	*a* 3 N 2 *b*	6·41	,,
18	9 2	*a* 5 N 0·5 *b*	6·53	,,
21	11 15	*a* 5 N 1 *b*	6·51	,,
Oct. 3	8 30	*a* 5 N 1 *b*	6·51	,,
6	7 25	*a* 5 N 1 *b*	6·51	,,
7	9 10	*a* 4 N 2 *b*	6·44	,,
14	9 35	*a* 7 N = *b*	6·62	,,
19	9 25	*a* 7 N	6·74	,,
Nov. 1	9 37	*b* 10 N 5 *c*	7·16	$6\frac{1}{2}$
3	8 20	*a* 9 N	6·88	Op.
3	10 5	*a* 12 N, *b* 7 N 6 *c*	7·17	$6\frac{1}{2}$
15	12 50	*a* 11 N, *b* 4 N	6·90	Op.
Dec. 10	13 55	*a* 13 N, *b* 7 N	7·07	,,
10	15 20	*b* 12 N = *c*	7·41	$2\frac{3}{4}$
18	15 45	*b* 10 N, *c* 1 N	7·37	,,
1902. Jan. 14	13 40	*b* 10 N, *c* 3 N	7·44	,,
31	12 15	*c* 15 N 17 *h*	8·19	,,
Mar. 4	11 5	*c* 16 N 11 *h*, N 8 *g*	8·34	,,
5	11 15	*c* 15 N 15 *h*, N 8 *g* 9 *h*	8·14	,,
6	8 30	*c* 17 N 11 *h*, N 8 *g*	8·36	,,
Apr. 6	8 30	*g* = N 10 *h*	8·55	,,
24	9 5	*g* 2 N 5 *h*	8·80	,,
28	8 50	N 2 *g*, N 8 *h*	8·55	,,

Notes.

1901.
June 26. A little hazy.
July 28. Object-glass slightly dewed in last observation.
Aug. 3. Thin cirrus cloud may have slightly affected the result.
4. A little thin cloud about.
9. Very clear generally, but patches of haze.
Sept. 1. Slight haze. Sky very bright.
Dec. 10. Exceedingly clear. Nova just distinctly visible in the opera-glass.

Excepting where otherwise noted above, it may be assumed that the conditions were favourable.

The observations show that there was a decided temporary increase in the brightness of the Nova on 1901 June 24; but this seems to be the last instance of the kind, the remarkable fluctuations in brightness having almost completely subsided after this date. I feel confident, however, that some of the smaller changes recorded later were real, and not due simply to errors of observation. In particular the increased brightness of the star on September 5 was undoubtedly real. Apart from these slight changes there has been a nearly continuous decline in brightness. The Nova was seen for the last time with the opera glass on December 10, an exceedingly clear night.

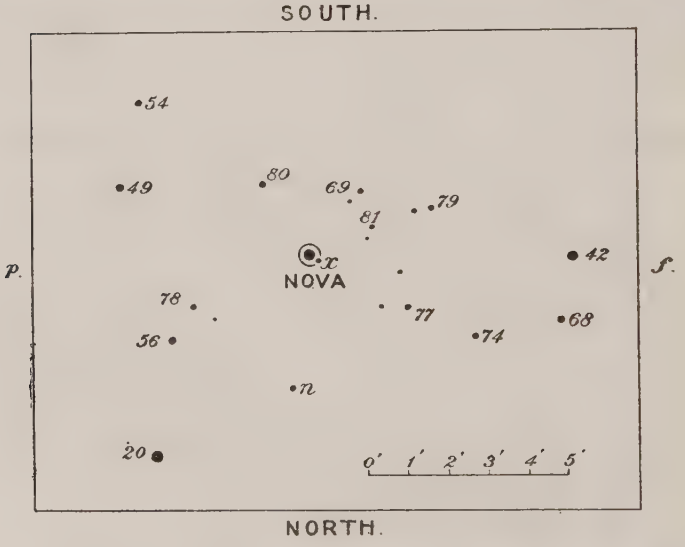
Notes on the Colour of the Star.

1901.
June 14. Little or no red colour, though appearance not the same as that of the comparison stars.
17. Colour seemed strongly reddish, but not more so than *b*.
23. Colour reddish, but not at all marked, and there even seemed at times to be a bluish tinge.
24. Yellowish with pale reddish flashes. On the whole the star was not as red as 36 Persei.
27. Hardly any red colour perceptible.
July 29. Hardly any red colour. The star was indeed slightly bluish, with an occasional yellowish red tinge. It was not nearly so red as *b*.
Aug. 6. Little or no red colour. Certainly not nearly so red as *b*.
8. Quite white, no red colour. No red colour with $6\frac{1}{2}$-inch refl., not even with a Kellner eyepiece which greatly intensifies yellow and red tints.
10. Bluish white, with perhaps occasionally a slight yellowish tinge.
11. Bluish white, with occasional pale reddish flashes.
12. Very pale reddish, not nearly so deep as *b*.
15. White, with occasionally a faint tinge of red or yellow.
18. White ($6\frac{1}{2}$-inch. refl. Kellner).
20. White.
22. White, with perhaps a slight reddish or yellowish tinge.
23. White.
26. White ($6\frac{1}{2}$-inch refl.). Nova had a perfectly stellar disc, with no trace of nebulosity.
27. White.
30. White ($6\frac{1}{2}$-inch refl.). The contrast between the orange red of *b* and the white of the Nova was very striking.
Sept. 1. White.
5. White, with perhaps a slight bluish tinge at times. With the $6\frac{1}{2}$-inch refl. white.
Nov. 1. Bluish white, even with the Kellner ($6\frac{1}{2}$-inch refl.).
Dec. 10. Colour seemed slightly greenish.
1902.
Jan. 14. Colour seemed bluish.
31. Distinctly bluish.

All the foregoing observations were made with the $2\frac{3}{4}$-inch refractor except where otherwise mentioned.

On the Photograph of 1901 *February* 20.

Short particulars of this photograph will be found in the *Monthly Notices*, vol. lxi. p. 337. As it appears that this was the last photograph taken before the apparition of the Nova, it becomes a matter of some interest to determine the magnitude of the faintest star shown by it. Visual estimates of the magnitudes of the fainter stars in this region have been published by Father Hagen * and Professor Aitkin.† The former used a 12-inch refractor, the latter a 36-inch refractor. The positions of most of the stars in the accompanying diagram have been



copied from Aitkin's chart, which is based on micrometer measures. The other stars, with the exception of x, have been added by estimation from Hagen's chart, and the positions of these are consequently not very exact. The numbers of the stars are from Hagen's catalogue. The following is a list of the fainter stars which are visible near the place of the Nova on the photograph of 1901 February 20, with the magnitudes as estimated by Aitkin ‡ and Hagen.

* "Second Chart and Catalogue for observing Nova Persei." See *Popular Astronomy*, vol. ix. p. 279.

† *Publications A.S.P.* vol. xiii. p. 68.

‡ Aitkin remarks that his estimates must be considered as relative rather than absolute.

Star.	Aitkin.	Hagen.	Star.	Aitkin.	Hagen.
49	...	11·0	77	13·0	12·7
54	...	11·4	78	13·2	12·8
56	12·5	11·4	80	13·0	(13)
68	...	12·1	*n*	13·8	...
74	...	12·4			

It seems certain from the foregoing list that if the new star had been as bright as 12·5 mag. on the photometric scale,* it must have left an impression upon this plate, unless it was of a red colour at the time.

In the *Astronomische Nachrichten*, No. 3755, Professor Ceraski has drawn attention to a star of about the 12th magnitude found by M. Blajko upon one of the Moscow photographs† very near to the place of the Nova, which star was completely invisible in a 15-inch refractor in 1901 December. What appears to be the same star is shown, not only by the photograph of 1901 February 20, but also by several other of my photographs of earlier date. The coordinates of the position of the star given by Ceraski are

$$\alpha = \alpha \text{ Nova} + 0^{s}\cdot 31 \qquad \delta = \delta \text{ Nova} - 7''.$$

Those from measures of the plate of 1901 February 20 are (for 1855)

$$\alpha = \alpha \text{ Nova} + 0^{s}\cdot 88. \qquad \delta = \delta \text{ Nova} + 7''.$$

These positions though not identical are so close that they doubtless refer to the same object. A high degree of accuracy is not to be expected from my measures, as the focal length of the portrait lens with which the photograph was taken is rather short (about 20 inches), and the star discs, even of the faintest stars, are somewhat large, owing to the region of the Nova falling near the edge of the plate. Nevertheless I do not think that the above difference of position can be in error by more than five seconds of arc. The position of x was measured on the plate of 1901 February 20; that of the Nova on a photograph taken on 1902 March 4, by which time the star had faded so much that its image is not very large. The two photographs were taken with the same instrument and under almost exactly similar conditions, and there can be no question as to a possible identification of the Nova with x. The faint star *Hagen* 80 is plainly visible on both plates, and it is evident, even to the eye, that the distance between this star and x is greater than that between it and the Nova.

The question as to what has become of x is a somewhat interesting one. As already stated it was invisible with the

* Hagen's magnitudes agree closely with the photometric determinations of Müller and Kempf down to the 9th magnitude.

† The photograph was obtained 1899 January 30.

15-inch Moscow refractor in 1901 December, whilst Aitkin failed to perceive it with the Lick 36-inch refractor in the spring of the same year.* It is, of course, possible that it is a long period variable, so that its invisibility may be only temporary, but the photographs do not seem to indicate variability. As already mentioned it is shown on several of the photographs taken here ; and the following are the estimated photographic magnitudes of x on the different plates, assuming Hagen's visual magnitudes for the stars 49 and 54, and a step value of 0·07 mag.

Date.	Observations.	Magnitude.
1900 Dec. 22	(49) 7 x, (54) 10 x	11·79
1901 Jan. 15	(49) 12 x, (54) 10 x	11·97
25	(49) 12 x, (54) 10 x	11·97
Feb. 20	(49) 10 x, (54) 9 x	11·86

It will be seen that there is here little indication of variability.† The star is also said to be about 12 mag. on the Moscow photograph of 1899 January 30.

Hove: 1902 *May* 20.

Since the above was written Professor Ceraski has very kindly sent me an enlarged print from the Moscow photograph of 1899 January 30. This shows that the brightness of M. Blajko's star is about the same as that of the star x upon my photographs. The position, however, although very close, does not appear to be quite identical, so that it is difficult to conclude with absolute certainty that the same object is represented. This nevertheless is probably the case, the slight difference in position being perhaps due to photographic causes.

Professor E. E. Barnard has recently published micrometer measures of the faint stars in the vicinity of *Nova Persei* made by him with the 40-inch Yerkes refractor (see *Astronomische Nachrichten*, No. 3796). The position of the star x as measured on the photograph of 1901 February 20 corresponds very closely with that of Barnard's star No. 1, the magnitude of which is given by him as 14·7 (position angle 66°·59, dist. 19″·44 from the Nova). This star was overlooked by Aitkin with the 36-inch Lick refractor in the spring of 1901, but the great brightness of the Nova at that time would no doubt account for this.

* The star was looked for here unsuccessfully with the 6½-inch reflector in August or September of 1901, but owing to the brightness of the Nova at that time no importance can be attached to this negative evidence.

† The slightly greater brightness on 1900 December 22 is not real, but due to the fact that the star 49 is abnormally faint on this plate, so as to be slightly fainter than 54, apparently from a photographic defect.

Nova Persei. By Thos. W. Backhouse.

The following table gives details of my observations of Nova *Persei* :—Column 1 gives the date, column 2 the Greenwich mean time of the observation, column 3 the power of instrument used, 4 denoting opera-glasses, 9 the finder, and 20 a $4\frac{1}{4}$-inch refracting telescope. o.f. in this column denotes that the instrument was out of focus. Column 4 gives the assumed relative absorption for the night, calling it 1·0 when it is as clear as it is ever likely to be at the place of observation ; column 5 gives the assumed zenithal absorption in magnitude ; column 6 gives the calculated value of a step, column 7 the resulting magnitudes of the Nova, and 8 the comparison stars.

The last column is reserved for any notes to the observations, as hindrances &c. When the observation is made anywhere else than at Sunderland the place of observation is given in this column.

The method of comparison used is that of Argelander, namely, by step estimations, the Nova being compared with the stars named in column 8. First the magnitudes of the comparison stars in each sequence were computed, using as standards the Harvard photometric magnitudes taken from the Harvard Photometry, with the exception of those for *t*, *v*, *w*, and y^2, which are from the Harvard Durchmusterung. An allowance has been made in the case of *β Geminorum*, *κ Persei*, *t*, and y^2, on account of their ruddy colour, such stars appearing fainter to me than to the Harvard observers. Then an average of these resulting magnitudes for each star was taken, and these averages were adopted as standards for computing the Nova.

t and y^2 have sometimes been observed, but have not been used for obtaining the magnitude of the Nova unless inserted in column 8. Allowance has been made for atmospheric absorption in the cases where it is given in columns 4 and 5 ; in other cases it was not thought it would appreciably affect the result.

The stars with which the Nova has been compared are in *Perseus*, with the exception of *Capella*, *α Canis Minoris*, and *α* and *β Geminorum*, but I have used letters to denote the smaller stars, their identification being as follows :—

u = 36 Persei	v = B.D.+44°, 757 }
s = B.D.+45°, 811	„ 759 }
z = B.A.C. 1172	w = „ +43°, 730
r = B.D.+45°, 804	y = „ +44°, 734
t = „ +44°, 648	y^2 = „ +44°, 732

When the observation of y is thought to have included the

neighbouring star y^2, the observed magnitude of the combination has been used.

The adopted magnitudes of the stars are given below with the Harvard photometric value.

	Adopted Mag.	Harvard Mag.		Adopted Mag.	Harvard Mag.
α Can. Min.	0·49	0·46	30 Persei	5·47	5·37
β Gem.	1·29	1·12	*s*	5·57	5·64
α „	1·66	1·56	*z*	5·74	5·71
α Persei	1·98	1·94	*r*	5·96	6·14
β „	2·19	2·31	*y* & y^2	6·04	5·80
ε „	3·04	3·04	*y*	6·27	6·04
ν „	4·00	4·00	*t*	6·75	6·37
κ „	4·11	3 95	*v*	6·60	6·82
32 „	4·89	4·84	*w*	6·74	6·91
u „	5·35	5·40	y^2	...	7·32

Sometimes some of the stars were observed in darker sky than others in the same comparison, but no account has been taken of this, as the differences would only be slight.

In two cases where the step value came out very high an assumed value of ·07 magnitude has been used.

In spite of the ruddy colour of the Nova during a considerable part of its apparition it did not appear to be relatively brighter in twilight or moonlight than in a dark sky, as ruddy stars usually do.

Date. 1901.	G.M.T. h m	Power.	Rel. Abs.	Z. Abs.	S. Value.	Mag. of Nova.	Comparison Stars.	Notes.
Feb. 22	11 5	...	...	...	...	Abt. 0·8	...	Sky covered with clouds not uniform.
24	6 23	...	...	...	..	Abt. 0·2	...	S. Shields. Owing to bright twilight, and the sky being covered with more or less cloud, only two stars are visible to the naked eye, Nova Persei and Capella (H.P. mag. 0·2). Owing to irregularities in the clouds it is impossible to tell which is the brighter.
26	10 15	...	1·5	·356	·072	1·27	α Can. Min.; β Gem., α Gem.; α.	Bright moonlight.
26	12 11	...	1·2	·320	·08	1 21	β Gem., α Gem.	„ „

Date. 1901.	G.M.T. h m	Power.	Rel. Abs.	Z. Abs.	S. Value.	Mag. of Nova.	Comparison Stars.	Notes.
Feb. 27	9 35	...	1·5	·356	·065	1·46	β Gem., α Gem. α	Bright moonlight.
Mar. 1	10 20	...	1·4	·344	·085	2·10	α, β.	
2	7 10	...	...	...	·153	2·51	,,	Moonlight. Altitudes practically equal.
3	9 50	...	1·0	·296	·068	2·41	α, β, ϵ.	Bright moonlight.
5	7 17	...	...	...	·07	2·54	,,	Altitudes equal.
7	7 55	...	...	...	·079	2·91	β, ϵ.	,, ,,
8	9 0	...	...	...	·075	3·12	ϵ	,, ,,
9	10 55	...	...	...	·099	3·40	ϵ, ν.	,, ,,
12	9 5	...	...	...	·067	3·52	,,	,, ,,
13	8 35	...	...	...	·075	3·80	,,	Shields. Altitudes equal.
20	7 40	...	1·0	·296	·094	3·60	,,	Twilight.
20	10 20	...	1·0	·263	·078	3·67	,,	
21	9 15	...	1·0	·263	·082	3·86	,,	
21	11 45	...	...	...	...	4·00	ν	Nova = ν Persei. Altitudes equal.
23	7 51	...	1·0	·296	·067	3·85	ϵ, ν.	Stockton. Twilight.
23	8 20	...	1·0	·279	·067	3·85	,,	Norton, near Stockton. Slight moonlight.
25	10 53	4 o.f.	...	...	·068	5·44	ν, 32, 30	Altitudes equal.
26	10 20	4 o.f.	1·0	·296	·102	4·10	ν, 32.	Bright moonlight.
26	11 50	4 o.f.	1·0	·296	·079	4·00	,,	,, ,,
28	9 15	4 o.f.	1·4	·344	·055	5·00	32, 30	,, ,,
28	11 35	4 o.f.	1·4	·344	·066	4·80	ν, 32	,, ,,
28	12 0	4 o.f.	1·2	·320	·063	4·85	,,	,, ,,
28	16 18	4 o.f.	1·0	·296	·04	4·73	,,	Twilight.
30	8 40	4 o.f.	1·0	·296	...	3·99	ν	Nova = ν. Brt. moonlight.
31	8 5	4 o.f.	...	...	·064	4·40	ν, 32	Brt. moonlight, alts. equal.
31	8 42	4 o.f.	...	...	·054	4·39	,,	,, ,,
31	9 17	4 o.f.	...	...	·055	4·39	,,	,, ,,
31	9 58	4 o.f.	...	...	·056	4·35	,,	,, ,,
31	10 27	4 o.f.	...	...	·056	4·35	,,	,, ,,
31	11 41	4 o.f.	...	...	·06	4·34	,,	Bright moonlight, altitudes practically equal.
Apr. 1	7 56	4 o.f.	1·1	·308	·064	4·19	,,	Bright twilight and moonlight.

Date. 1901.	G.M.T. h m	Power.	Rel. Abs.	Z. Abs.	S. Value.	Mag. of Nova.	Comparison Stars.	Notes.
Apr. 1	9 32	4 o.f.	1·1	·308	·073	4·33	*ν*, 32	Bright moonlight.
1	10 24	4 o.f.	1·1	·308	·066	4·30	,,	,, ,,
1	12 35	4 o.f.	1·1	·308	·06	4·31	,,	,, ,,
4	7 59	4 o.f.	...	...	·079	4·17	,,	Bright twilight, altitudes practically equal.
4	8 21	4 o.f.	...	...	·079	4·17	,,	Brightish twilight, altitudes practically equal.
4	8 45	4 o.f.	...	...	·087	4·10	,,	Brightish moonlight or twilight, alts. equal.
4	9 52	4 o.f.	...	...	·073	4·16	,,	Bright moonlight, altitudes equal.
4	10 29	4 o.f.	...	...	·076	4·12	,,	,, ,,
4	11 21	4 o.f.	1·0	·296	·07	4·12	,,	Bright moonlight.
5	9 0	4 o.f.	1·0	·279	·073	4·40	,,	Slight twilight or moonlight.
5	9 45	4 o.f.	1·0	·296	·066	4·40	,,	Moonlight.
8	8 35	4 o.f.	1·0	·296	·075	4·53	,,	South Shields. Twilight.
8	9 35	4 o.f.	1·0	·263	·07	4·46	,,	
8	10 4	4 o.f.	1·0	·263	·063	4·41	,,	
8	15 42	4 o.f.	1·1	·308	·037	4·35	,,	Bright twilight and moonlight.
9	15 18	9	1·1	·308	·039	4·62	,,	Bright moonlight.
9	15 27	4 o.f.	1·1	·308	·041	4·63	,,	,, ,,
11	9 18	4 o.f.	...	...	·041	5·56	30, *z*.	Alts. practically equal.
11	9 39	4 o.f.	...	...	·044	5·55	,,	,, ,, ,,
12	9 12	4 o.f.	...	...	·083	4·67	*ν*, 32.	Altitudes equal.
13	8 54	4 o.f.	...	...	·058	4·42	,,	West Hartlepool. Slight twilight, alts. equal.
13	9 25	4 o.f.	...	...	·056	4·40	,,	W. Hartlepl. Alts. equal.
14	8 27	4 o.f.	...	...	·073	5·66	30, *z*.	West Hartlepool. Twilight, altitudes equal.
14	8 31	4	...	...	·11	5·60	,,	,, ,, ,,
14	8 49	4 o.f.	...	...	·055	5·55	,,	West Hartlepool. Slight twilight, alts. equal.
14	9 54	4 o.f.	...	...	·047	5·58	30; *z*	W. Hartlep'l. Alts. equal.
	10 5	4 o.f.	...	...	·044	5·57	,,	,, ,, ,, ,,
	10 39	4 o.f.	1·1	·280	·023	5·56	,,	,, ,, Town smoke.

Date. 1901.	G.M.T. h m	Power.	Rel. Abs.	Z. Abs.	S. Value.	Mag. of Nova.	Comparison Stars.	Notes.
Apr. 14	15 15	4	1·0	·263	·063	5·74	30; *z*; *y*	W. Hartlep'l. Twilight.
	15 33	4	1·0	·263	·195	5·69	30, *z*	,, ,, Step value assumed ·07 mag. Brightish twilight.
15	8 44	4 o.f.	...	...	·045	5·59	,,	Twilight. Alts. equal.
	9 15	4 o.f.	...	...	·066	5·67	,,	Slight twilight. Alts. equal
16	10 35	9 o.f.	...	...	·05	5·37	30	Town light. Alts. equal
18	15 28	4	...	...	·100	4·65	*κ*; 32	Hurworth. Alts. equal.
20	9 5	4	1·3	·313	·06	5·74	30; *z*	Twilight.
	9 34	4 o.f.	1·7	·379	·032	5·65	30; *z*; *y* & y^2	
21	9 29	4	2·0	·423	·13	5·67	30, *z*	Slight twilight and moonlight. Step value assumed ·07 mag.
24	9 47	4 o.f.	...	...	·066	5·57	,,	Moonlight. Alts. equal.
25	10 33	4	1·0	·263	·053	5·79	30; *z*; *y*	,,
26	9 22	4	1·0	·263	·048	5·72	30; *z*	,,
May 4	10 5	20	...	...	·104	5·79	30; *y*	Bright twilight. Alts. equal.
15	10 9	4	1·2	·324	·049	5·85	,,	Torquay. Twilight.
16	10 15	4	1·3	·330	·037	5·83	,,	,, Brightish twilight.
20	13 40	4	1·0	·263	·045	5·57	32; 30	London. Brightish twilight.
24	13 25	4	1·0	·263	·073	5·78	32; 30; *y*	London. Brightish twilight.
June 1	12 20	20 o.f.	1·0	·296	·063	5·77	30; *y*	Bright twilight.
5	12 10	20 o.f.	1·0	·296	·066	5·92	,,	,, ,,
		20	1·0	·263	·061	6·05	32; *u*; 30; *y*; *v*; *w*	,, ,,
8	11 10	20	1·5	·346	·076	4·69	*ν*; *κ*; 32; 30	,, ,,
9	12 15	20	1·0	·263	·057	5·95	32; *u*; 30; *y*; *v*	,, ,,
10	11 3	20	1·0	·263	·054	5·96	30; *y*	,, ,,
	12 15	20 o.f.	1·0	·296	·058	5·96	,,	,, ,,
	12 25	20	1·0	·263	·046	5·87	,,	,, ,,
11	11 12	20	1·0	·263	·056	5·03	32; 30	,, ,,
12	11 20	20	1·0	·263	·073	5·85	30; *y*	,, ,,
	11 35	20	1·0	·263	·063	5·90	,,	,, ,,

Date. 1901.	G.M.T. h	m	Power.	Rel. Abs.	Z. Abs.	S. Value.	Mag. of Nova.	Comparison Stars.	Notes.
June 12	12	10	20	1·0	·263	·066	5·93	30; *y*	Bright twilight.
			20 o.f.	1·0	·296	·069	5·87	„	„ „
18	12	15	20	·5	·356	·059	6·04	30; *z*; *y*	„ „
July 2	11	23	20	1·3	·313	·065	5·90	30; *y*	„ „
13	10	45	20	1·2	·296	·053	6·09	*s*; *z*; *r*; *y*	„ „
15	12	15	4	1·0	·263	·058	5·70	30; *z*; *y*	Brightish twilight.
26	13	20	4 o.f.	...	...	·063	5·84	30; *y* & y^2	Alts. equal. Slight twilight.
Aug. 4	11	20	4	...	...	063	6·03	*z*	Alts. equal. Bright moonlight.
19	13	0	4 o.f.	...	...	·066	5·94	*u*; 30; *s*; *z*; *r*; *y* & y^2	Alts. equal.
21	11	50	4 o.f.	...	...	·063	5·89	*z*; *y* & y^2	„ „
22	10	40	4 o.f.	...	...	·063	5·94	„	„ „ Sky light with electric light.
24	10	40	20 o.f.	...	...	·063	6·18	*z*; *y*	Alts. equal. Bright moonlight.
26	11	50	4 o.f.	...	...	...	6·04	*y* & y^2	Moonlight. Alts. equal.
	14	0	20 o.f.	...	...	·056	6·20	*u*; 30; *s*; *z*; *r*; *y*; *v*	Alts. equal.
	14	45	4 o.f.	...	...	·052	6·14	*u*; 30; *s*; *z*; *r*; *y* & y^2; *v*	„ „
27	10	40	4	...	...	·063	6·14	*z*; *y*	„ „ Bright moonlt.
28	10	40	20 o.f.	...	...	·051	6·26	*s*; *z*; *r*; *y*; *v*	„ „ „ „
31	9	50	20 o.f.	...	...	·042	6·27	*z*; *r*; *y*; *v*	„ „ „ „
Sept. 1	12	15	20 o.f.	...	...	·044	6·25	*s*; *z*; *r*; *y*; *v*	„ „ „ „
4	10	15	4 o.f.	...	...	·042	6·06	*s*; *z*; *r*; *y* & y^2	„ „ Slight moonlt.
	10	30	20 o.f.	...	...	·069	6·29	*r*; *y*; *v*	„ „ Moonlight.
	11	10	4	...	...	·06	6·15	„	„ „ „
5	10	50	4 o.f.	...	...	·063	6·08	*z*; *r*; *y* & y^2; *v*	„ „ Slight moonlt.
	11	50	20 o.f.	...	...	·055	6·25	*z*; *r*; *y*; *v*	„ „ „ „
			4 o.f.	...	...	·061	6·21	*y*	Broughty Ferry. Alts. equal.
26	10	40	20 o.f.	...	...	·044	6·42	*z*; *r*; *y*; *v*	Alts. equal. Moonlight.
Oct. 4	10	15	4 o.f.	...	...	·074	6·47	*r*; *y* & y^2; *v*	„
	10	20	20 o.f.	...	...	·063	6·55	*r*; *y*; *v*	„
5	10	3	4 o.f.	...	...	·084	6·36	*y* & y^2; *v*	„

Date. 1901.	G.M.T. h	m	Power.	Rel. Abs.	Z. Abs.	S. Value.	Mag. of Nova.	Comparison Stars.	Notes.
Oct. 6	10	3	4 o.f.	...	...	·063	6·40	*y* & y^2; *v*	Alts. equal.
7	10	25	4 o.f.	...	...	·068	6·40	,,	,,
8	11	55	4 o.f.	...	...	·063	6·40	,,	,,
9	9	42	20 o.f.	...	...	·067	6·57	*y*; *v*	,,
10	10	25	4 o.f.	...	...	·078	6·42	*y* & y^2; *v*	,,
	10	40	20 o.f.	...	...	·078	6·51	*y*; *v*	,,
11	10	30	4 o.f.	...	...	·055	6·41	*y* & y^2; *v*	,,
17	9	50	4 o.f.	...	...	·063	6·43	,,	,,
25	10	50	20 o.f.	...	...	·103	6·74	*y*; *v*	,, Moonlight.
Nov. 12	7	55	4 o.f.	...	...	·063	6·66	*t*; *v*	,,
15	8	15	4 o.f.	...	...	·063	6·69	,,	,,

West Hendon House, Sunderland.

Ephemeris for Physical Observations of

Greenwich Noon. 1902.	P.	L−O.	B.	A−L.	*B.*	Q.	E.
	°	°	°	°	°	°	°
Oct. 5	3·03	231·89	+20·90	...	+10·66	289·26	29·24
7	3·82	233·14	21·19	...	11·02	289·56	29·51
9	4·60	234·39	21·47	29·22	11·38	289·85	29·79
11	5·37	235·64	21·74	...	11·73	290·12	30·06
13	6·14	236·89	22·00	...	12·08	290·38	30·33
15	6·90	238·14	22·25	...	12·43	290·63	30·59
17	7·66	239·39	22·49	30·75	12·77	290·87	30·85
19	8·41	240·63	22·71	...	13·11	291·10	31·11
21	9·16	241·88	22·92	...	13·44	291·32	31·36
23	9·90	243·12	23·12	...	13·77	291·53	31·61
25	10·64	244·36	23·31	32·24	14·10	291·73	31·86
27	11·37	245·60	23·48	...	14·42	291·92	32·11
29	12·09	246·83	23·64	...	14·74	292·10	32·34
31	12·80	248·06	23·79	...	15·06	292·28	32·58
Nov. 2	13·51	249·29	23·94	33·67	15·37	292·44	32·81
4	14·21	250·52	24·08	...	15·68	292·59	33·04
6	14·90	251·74	24·20	...	15·99	292·73	33·26
8	15·58	252·95	24·31	...	16·29	292·86	33·48
10	16·25	254·16	24·41	34·99	16·59	292·98	33·68
12	16·92	255·37	24·49	...	16·88	293·09	33·89
14	17·58	256·57	24·56	...	17·17	293·19	34·09
16	18·22	257·75	24·62	...	17·46	293·28	34·28
18	18·86	258·93	24·67	36·26	17·74	293·36	34·47
20	19·49	260·11	24·71	...	18·02	293·43	34·65
22	20·11	261·28	24·75	...	18·29	293·50	34·82
24	20·71	262·44	24·78	...	18·55	293·56	34·98
26	21·30	263·58	24·80	37·35	18·81	293·61	35·13
28	21·88	264·72	24·81	...	19·07	293·65	35·28
30	22·44	265·84	24·80	...	19·32	293·68	35·41
Dec. 2	22·99	266·95	24·78	...	19·57	293·70	35·54
4	23·53	268·05	24·75	38·23	19·81	293·71	35·66
6	24·07	269·15	24·71	...	20·05	293·72	35·77
8	24·59	270·23	24·66	...	20·29	293·72	35·87
10	25·10	271·30	24·61	...	20·52	293·71	35·96
12	25·59	272·35	+24·55	38·91	+20·75	293·69	36·04

Mars, 1902–3. By A. C. D. Crommelin.

Greenwich Noon. 1902.	⊙	Light Time.	Appar. Diam.	Defect of Illumination.	Central Meridian.	Passage of Zero Meridian.	
	°	m	″	″	°	h m	h m
Oct. 5	...	16·836	4·60	0·29	106·86	17 20·64	18 0·61
7	...	16·725	4·62	0·30	87·42	18 40·57	19 20·53
9	27·46	16·612	4·66	0·31	67·98	20 0·49	20 40·45
11	...	16·498	4·69	0·32	48·54	21 20·40	22 0·36
13	...	16·383	4·72	0·33	29·10	22 40·31	23 20·25
15	...	16·264	4·76	0·33	9·67	...	0 0·19
17	31·13	16·144	4·79	0·34	350·24	0 40·13	1 20·06
19	...	16·023	4·82	0·35	330·81	2 0·00	2 39·94
21	...	15·900	4·86	0·36	311·38	3 19·87	3 59·81
23	...	15·775	4·90	0·37	291·95	4 39·74	5 19·67
25	34·77	15·648	4·94	0·37	272·52	5 59·60	6 39·52
27	...	15·519	4·98	0·38	253·10	7 19·44	7 59·36
29	...	15·388	5·02	0·39	233·68	8 39·28	9 19·19
31	...	15·256	5·07	0·40	214·26	9 59·10	10 39·00
Nov. 2	38·38	15·123	5·11	0·41	194·85	11 18·90	11 58·79
4	...	14·988	5·16	0·42	175·44	12 38·67	13 18·55
6	...	14·851	5·21	0·43	156·04	13 58·42	14 38·29
8	...	14·712	5·26	0·43	136·64	15 18·15	15 58·01
10	41·97	14·572	5·31	0·44	117·25	16 37·87	17 17·72
12	...	14·430	5·36	0·45	97·86	17 57·56	18 37·40
14	...	14·287	5·41	0·46	78·48	19 17·23	19 57·05
16	...	14·143	5·47	0·47	59·10	20 36·86	21 16·66
18	45·53	13·997	5·53	0·48	39·73	21 56·46	22 36·24
20	...	13·850	5·58	0·49	20·38	23 16·00	23 55·74
22	...	13·701	5·64	0·50	1·04	...	0 35·45
24	...	13·551	5·70	0·51	341·71	1 15·16	1 54·87
26	49·08	13·400	5·77	0·52	322·39	2 34·57	3 14·26
28	...	13·248	5·84	0·53	303·08	3 53·94	4 33·61
30	...	13·094	5·91	0·54	283·78	5 13·27	5 52·92
Dec. 2	...	12·939	5·98	0·55	264·49	6 32·56	7 12·18
4	52·62	12·783	6·05	0·56	245·21	7 51·79	8 31·39
6	...	12·627	6·12	0·57	225·94	9 10·98	9 50·56
8	...	12·469	6·20	0·59	206·68	10 30·12	11 9·66
10	...	12·311	6·28	0·60	187·43	11 49·19	12 28·71
12	56·14	12·152	6·36	0·61	168·20	13 8·23	13 47·70

Greenwich Noon. 1902.	P.	L−O.	B.	A−L.	*B.*	Q.	E.
	°	°	°	°	°	°	°
Dec. 14	26·07	273·38	+24·49	...	+20·97	293·67	36·10
16	26·53	274·40	24·42	...	21·19	293·64	36·15
18	26·98	275·40	24·34	...	21·40	293·60	36·20
20	27·42	276·38	24·25	39·29	21·60	293·56	36·23
22	27·84	277·35	24·16	...	21·80	293·51	36·24
24	28·24	278·30	24·06	...	21·99	293·45	36·24
26	28·63	279·23	23·96	...	22·18	293·38	36·22
28	29·01	280·14	23·85	39·38	22·36	293·30	36·18
30	29·38	281·03	23·73	...	22·54	293·21	36·13
1903.							
Jan. 1	29·73	281·90	23·61	...	22·71	293·11	36·06
3	30·07	282·75	23·49	...	22·88	293·02	35·97
5	30·39	283·57	23·37	39·08	23·04	292·92	35·85
7	30·70	284·36	23·25	...	23·20	292·82	35·72
9	31·00	285·13	23·12	...	23·35	292·72	35·57
11	31·28	285·88	22·99	...	23·50	292·61	35·40
13	31·54	286·60	22·86	38·37	23·64	292·50	35·20
15	31·79	287·29	22·73	...	23·77	292·38	34·98
17	32·03	287·95	22·60	...	23·90	292·26	34·73
19	32·25	288·59	22·47	...	24·02	292·14	34·46
21	32·46	289·19	22·34	37·17	24·14	292·01	34·15
23	32·65	289·76	22·22	...	24·25	291·87	33·82
25	32·83	290·29	22·10	...	24·36	291·73	33·45
27	33·00	290·78	21·99	...	24·46	291·60	33·05
29	33·15	291·24	21·88	35·41	24·55	291·47	32·62
31	33·29	291·66	21·77	...	24·64	291·32	32·15
Feb. 2	33·41	292·05	21·66	...	24·72	291·15	31·65
4	33·52	292·39	21·56	...	24·79	290·98	31·11
6	33·61	292·69	21·47	33·03	24·86	290·80	30·53
8	33·69	292·95	21·39	...	24·92	290·61	29·91
10	33·76	293·17	21·32	...	24·98	290·42	29·24
12	33·81	293·35	21·26	...	25·03	290·21	28·54
14	33·85	293·47	21·21	29·94	25·08	290·01	27·79
16	33·87	293·52	21·17	...	25·12	289·80	26·99
18	33·87	293·54	21·14	...	25·15	289·57	26·14
20	33·86	293·51	21·11	...	25·17	289·33	25·24
22	33·85	293·45	21·09	26·02	25·19	289·08	24·29
24	33·81	293·34	+21·10	...	+25·20	288·83	23·30

Greenwich Noon. 1902.	⊙	Light Time.	Appar. Diam.	Defect of Illumination.	Central Meridian.	Passage of Zero Meridian.	
	°	m	″	″	°	h m	h m
Dec. 14	...	11·992	6·45	0·62	148·99	14 27·16	15 6·61
16	...	11·831	6·54	0·63	129·79	15 46·04	16 25·45
18	...	11·670	6·63	0·64	110·61	17 4·84	17 44·20
20	59·64	11·508	6·72	0·65	91·45	18 23·53	19 2·84
22	...	11·346	6·82	0·66	72·31	19 42·14	20 21·42
24	...	11·183	6·92	0·67	53·19	21 0·68	21 39·92
26	...	11·019	7·02	0·68	34·09	22 19·14	22 58·35
28	63·14	10·856	7·13	0·69	15·00	23 37·54	...
30	...	10·692	7·24	0·70	355·93	0 16·71	0 55·86
1903.							
Jan. 1	...	10·528	7·35	0·71	336·88	1 34·99	2 14·08
3	...	10·363	7·46	0·71	317·86	2 53·13	3 32·16
5	66·64	10·199	7·58	0·72	298·86	4 11·17	4 50·15
7	...	10·036	7·70	0·73	279·89	5 29·10	6 8·03
9	...	9·873	7·83	0·73	260·94	6 46·93	7 25·80
11	...	9·710	7·96	0·74	242·02	8 4·63	8 43·43
13	70·13	9·548	8·10	0·75	223·13	9 22·21	10 0·96
15	...	9·386	8·24	0·75	204·27	10 39·68	11 18·36
17	...	9·225	8·38	0·75	185·43	11 57·01	12 35·63
19	...	9·064	8·53	0·75	166·62	13 14·22	13 52·79
21	73·63	8·904	8·68	0·75	147·84	14 31·33	15 9·83
23	...	8·745	8·84	0·74	129·09	15 48·29	16 26·70
25	...	8·588	9·00	0·74	110·38	17 5·07	17 43·40
27	...	8·432	9·17	0·74	91·70	18 21·70	18 59·96
29	77·12	8·277	9·34	0·73	73·06	19 38·18	20 16·35
31	...	8·124	9·52	0·72	54·46	20 54·48	21 32·57
Feb. 2	...	7·974	9·70	0·72	35·90	22 10·62	22 48·63
4	...	7·826	9·88	0·71	17·38	23 26·61	...
6	80·62	7·679	10·07	0·69	358·89	0 4·56	0 42·44
8	...	7·534	10·26	0·68	340·45	1 20·26	1 58·03
10	...	7·392	10·46	0·66	322·05	2 35·76	3 13·44
12	...	7·253	10·66	0·64	303·70	3 51·07	4 28·64
14	84·13	7·116	10·87	0·63	285·40	5 6·16	5 43·63
16	...	6·983	11·08	0·61	267·14	6 21·06	6 58·44
18	...	6·853	11·29	0·59	248·93	7 35·77	8 13·04
20	...	6·726	11·50	0·56	230·77	8 50·25	9 27·40
22	87·65	6·603	11·71	0·53	212·67	10 4·49	10 41·52
24	...	6·485	11·93	0·49	194·62	11 18·49	11 55·40

Greenwich Noon. 1903.	P.	L—O.	B.	A—L.	*B.*	Q.	E.
	°	°	°	°	°	°	°
Feb. 26	33·75	293·16	+21·12	...	+25·21	288·56	22·24
28	33·67	292·90	21·14	...	25·21	288·26	21·14
Mar. 2	33·57	292·60	21·17	21·28	25·21	287·85	19·99
4	33·45	292·24	21·22	...	25·20	287·33	18·78
6	33·32	291·83	21·28	...	25·17	286·7	17·52
8	33·17	291·38	21·35	...	25·14	286·1	16·21
10	33·00	290·87	21·43	15·63	25·11	285·3	14·86
12	32·82	290·30	21·52	...	25·07	284·4	13·46
14	32·62	289·70	21·63	...	25·03	283	12·02
16	32·40	289·07	21·74	...	24·98	281	10·55
18	32·16	288·39	21·86	9·22	24·92	279	9·04
20	31·90	287·67	22·00	...	24·86	277	7·52
22	31·63	286·91	22·14	...	24·79	274	5·99
24	31·35	286·13	22·28	...	24·71	270	4·46
26	31·06	285·34	22·42	2·23	24·62	264	3·05
28	30·76	284·53	22·56	...	24·53	...	2·04
30	30·44	283·70	22·71	...	24·43	...	2·14
Apr. 1	30·10	282·85	22·85	...	24·33	147	3·26
3	29·77	282·03	23·00	5·04	24·22	140	4·73
5	29·45	281·23	23·14	...	24·10	134	6·29
7	29·13	280·45	23·29	...	23·98	129	7·87
9	28·81	279·68	23·43	...	23·85	125	9·46
11	28·50	278·93	23·57	12·08	23·71	121·9	11·03
13	28·20	278·20	23·71	...	23·56	120·6	12·59
15	27·90	277·53	23·84	...	23·41	119·6	14·11
17	27·63	276·93	23·97	...	23·25	118·8	15·60
19	27·37	276·36	24·09	18·59	23·09	118·0	17·06
21	27·13	275·82	24·21	...	22·92	117·36	18·47
23	26·91	275·30	24·33	...	22·75	116·86	19·84
25	26·72	274·85	24·44	...	22·57	116·43	21·16
27	26·55	274·48	24·55	24·41	22·38	116·06	22·43
29	26·41	274·16	24·65	...	22·19	115·73	23·65
May 1	26·29	273·90	24·75	...	21·99	115·43	24·82
3	26·20	273·70	24·85	...	21·78	115·17	25·95
5	26·13	273·55	24·95	29·27	21·56	114·97	27·01
7	26·09	273·46	25·04	...	21·34	114·80	28·03
9	26·08	273·43	25·13	...	21·11	114·65	29·00
11	26·08	273·47	+25·21	...	+20·88	114·51	29·92

Greenwich Noon. 1903.	⊙	Light Time.	Appar. Diam.	Defect of Illumination.	Central Meridian.	Passage of Zero Meridian.	
	°	m	″	″	°	h m	h m
Feb. 26	...	6·372	12·14	0·45	176·63	12 32·25	13 9·05
28	...	6·263	12·35	0·41	158·68	13 45·80	14 22·50
Mar. 2	91·19	6·158	12·56	0·37	140·79	14 59·14	15 35·72
4	...	6·058	12·77	0·33	122·95	16 12·24	16 48·69
6	...	5·964	12·97	0·29	105·17	17 25·08	18 1·42
8	...	5·875	13·16	0·25	87·44	18 37·71	19 13·95
10	94·73	5·791	13·35	0·21	69·76	19 50·15	20 26·31
12	...	5·714	13·53	0·18	52·11	21 2·44	21 38·53
14	...	5·643	13·70	0·15	34·50	22 14·58	22 50·56
16	...	5·578	13·86	0·12	16·94	23 26·47	...
18	98·30	5·520	14·01	0·09	359·44	0 2·30	0 38·12
20	...	5·468	14·14	0·07	341·97	1 13·92	1 49·71
22	...	5·423	14·26	0·04	324·51	2 25·49	3 1·25
24	...	5·385	14·36	0·02	307·06	3 36·99	4 12·71
26	101·89	5·355	14·44	0·01	289·64	4 48·41	5 24·08
28	...	5·332	14·50	0·00	272·25	5 59·72	6 35·33
30	...	5·316	14·54	0·00	254·87	7 10·91	7 46·51
Apr. 1	...	5·307	14·56	0·01	237·49	8 22·12	8 57·76
3	105·51	5·305	14·57	0·02	220·09	9 33·52	10 9·19
5	...	5·311	14·56	0·04	202·67	10 44·89	11 20·61
7	...	5·323	14·53	0·06	185·25	11 56·34	12 32·09
9	...	5·342	14·48	0·09	167·81	13 7·87	13 43·69
11	109·15	5·367	14·41	0·13	150·34	14 19·56	14 55·48
13	...	5·399	14·32	0·16	132·82	15 31·45	16 7·46
15	...	5·437	14·22	0·21	115·25	16 43·52	17 19·62
17	...	5·481	14·10	0·26	97·65	17 55·76	18 31·94
19	112·82	5·531	13·97	0·31	80·01	19 8·16	19 44·44
21	...	5·587	13·83	0·36	62·33	20 20·78	20 57·19
23	...	5·648	13·68	0·41	44·58	21 33·66	22 10·19
25	...	5·713	13·53	0·46	26·78	22 46·78	23 23·42
27	116·52	5·783	13·37	0·51	8·92	...	0 0·12
29	...	5·857	13·20	0·56	351·01	0 36·88	1 13·71
May 1	...	5·936	13·03	0·61	333·04	1 50·61	2 27·58
3	...	6·019	12·85	0·65	315·01	3 4·61	3 41·70
5	120·26	6·105	12·67	0·69	296·92	4 18·84	4 56·06
7	...	6·194	12·49	0·73	278·76	5 33·35	6 10·72
9	...	6·287	12·30	0·77	260·55	6 48·16	7 25·64
11	...	6·382	12·11	0·81	242·28	8 3·17	8 40·74

Greenwich Noon. 1903.	P.	L−O.	B.	A−L.	*B*.	Q.	E.
	°	°	°	°	°	°	°
May 13	26·12	273·55	+25·29	33·19	+20·64	114·39	30·80
15	26·18	273·68	25·36	...	20·39	114·29	31·63
17	26·26	273·87	25·43	...	20·14	114·19	32·41
19	26·37	274·11	25·50	...	19·88	114·10	33·15
21	26·50	274·40	25·56	36·26	19·62	114·01	33·85
23	26·65	274·73	25·62	...	19·35	113·94	34·51
25	26·82	275·11	25·68	...	19·07	113·88	35·13
27	27·01	275·54	25·73	...	18·79	113·82	35·72
29	27·22	276·02	25·77	38·55	18·50	113·76	36·26
31	27·45	276·53	25·80	...	18·21	113·71	36·77
June 2	27 70	277·08	25·83	...	17·91	113·66	37·25
4	27·95	277·66	25·85	...	17·61	113·62	37·70
6	28·22	278·29	25·86	40·18	17·30	113·58	38·11
8	28·52	278·97	25·87	...	16·98	113·54	38·50
10	28·82	279·67	25·87	...	16·66	113·50	38·86
12	29·12	280·40	25·86	...	16·33	113·46	39·20
14	29·44	281·15	25·85	41·22	16·00	113·42	39·5
16	29·76	281·93	25·84	...	15·66	113·37	39·79
18	30·08	282·74	25·82	...	15·32	113·33	40·05
20	30·41	283·58	25·79	...	14·97	113·28	40·29
22	30·75	284·43	25·75	41·83	14·61	113·24	40·51
24	31·10	285·31	25·69	...	14·25	113·20	40·71
26	31·46	286·23	25·61	...	13·88	113·15	40·89
28	31·82	287·17	25·51	...	13·51	113·11	41·05
30	32·19	288·16	25·40	41·98	13·14	113·06	41·19
July 2	32·55	289·18	25·29	...	12·76	113·02	41·32
4	32·91	290·20	25·17	...	12·37	112·96	41·43
6	33·27	291·23	25·04	...	11·98	112·89	41·52
8	33·62	292·26	24·90	41·78	11·59	112·81	41·61
10	33·97	293·31	24·75	...	11·19	112·72	41·68
12	34·31	294·37	24·59	...	10·79	112·63	41·73
14	34·65	295·45	24·42	...	10·39	112·53	41·77
16	34 98	296·55	24·25	41·39	9·98	112·43	41·80
18	35·31	297·67	24·07	...	9·56	112·32	41·82
20	35·63	298·80	23·87	...	9·14	112·20	41·82
22	35·94	299·94	23·65	...	8·72	112·07	41·82
24	36·24	301·09	23·41	40·77	8·29	111·94	41·81
26	36·53	302·25	+23·16	...	+7·86	111·80	41·78

Greenwich Noon, 1903.	⊙	Light Time.	Appar. Diam.	Defect of Illumination.	Central Meridian.	Passage of Zero Meridian	
	°	m	″	″	°	h m	h m
May 13	124·03	6·480	11·93	0·84	223·97	9 18·35	
							9 56·03
15	...	6·580	11·75	0·87	205·60	10 33·78	
							11 11·61
17	...	6·682	11·57	0·90	187·17	11 49·51	
							12 27·46
19	...	6·786	11·39	0·93	168·69	13 5·45	
							13 43·48
21	127·85	6·893	11·22	0·96	150·16	14 21·56	
							14 59·70
23	...	7·001	11·05	0·98	131·58	15 37·90	
							16 16·16
25	...	7·110	10·89	1·00	112·95	16 54·48	
							17 32·84
27	...	7·221	10·73	1·01	94·28	18 11·23	
							18 49·66
29	131·71	7·333	10·56	1·02	75·57	19 28·12	
							20 6·64
31	...	7·445	10·39	1·04	56·82	20 45·22	
							21 23·84
June 2	...	7·558	10·23	1·05	38·02	22 2·51	
							22 41·22
4	...	7·672	10·08	1·06	19·18	23 19·96	
							23 58·73
6	135·61	7·787	9·93	1·07	0·31	...	
							0 37·53
8	...	7·903	9·79	1·07	341·41	1 16·37	
							1 55·24
10	...	8·018	9·65	1·08	322·46	2 34·14	
							3 13·11
12	...	8·134	9·51	1·08	303·47	3 52·14	
							4 31·22
14	139·56	8·250	9·37	1·08	284·47	5 10·32	
							5 49·41
16	...	8·366	9·24	1·07	265·45	6 28·51	
							7 7·62
18	...	8·483	9·11	1·07	246·40	7 46·76	
							8 25·94
20	...	8·599	8·99	1·07	227·32	9 5·16	
							9 44·41
22	143·56	8·715	8·87	1·07	208·22	10 23·70	
							11 3·03
24	...	8·831	8·75	1·06	189·08	11 42·39	
							12 21·79
26	...	8 946	8·64	1·06	169·90	13 1·22	
							13 40·68
28	...	9 061	8·53	1·06	150·70	14 20·16	
							14 59·66
30	147·61	9·176	8·42	1·05	131·48	15 39·17	
							16 18·70
July 2	...	9·291	8·32	1·04	112·25	16 58·24	
							17 37·79
4	...	9·405	8·22	1·04	93·00	18 17·35	
							18 56·94
6	...	9·519	8·12	1·03	73·73	19 36 55	
							20 16·19
8	151·72	9·632	8·03	1·02	54·45	20 55·85	
							21 35·52
10	...	9·744	7·94	1·01	35·15	22 15·20	
							22 54·90
12	...	9·856	7·85	1·00	15·84	23 34·61	
							...
14	...	9·967	7·76	0·99	356·51	0 14·34	
							0 53·08
16	155·88	10·078	7·67	0·98	337·17	1 33·83	
							2 13·61
18	...	10·188	7·59	0·97	317·81	2 53·41	
							3 33·22
20	...	10·298	7·51	0·96	298·44	4 13·05	
							4 52·89
22	...	10·407	7·43	0·94	279·06	5 32·73	
							6 12·58
24	160·10	10·515	7·35	0·93	259 67	6 52·43	
							7 32·30
26	...	10·622	7·28	0·92	240·27	8 12·18	
							8 52·08

Greenwich Noon. 1903.	P.	L−O.	B.	A−L.	*B.*	Q.	E.
	°	°	°	°	°	°	°
July 28	36·81	303·42	+22·90	...	+7·42	111·65	41·74
30	37·07	304·60	22·63	...	6·98	111·49	41·70
Aug. 1	37·32	305·78	22·35	40·02	6·54	111·32	41·65
3	37·56	306·97	22·06	...	6·09	111·14	41·59
5	37·79	308·16	21·75	...	5·64	110·95	41·51
7	38·00	309·37	21·43	...	5·19	110·74	41·44
9	38·19	310·59	21·10	39·16	4·74	110·53	41·35
11	38·36	311·80	20·76	...	4·28	110·31	41·25
13	38·52	313·02	20·40	...	3·82	110·08	41·14
15	38·66	314·25	20·03	...	3·35	109·84	41·02
17	38·79	315·48	19·65	38·27	2·88	109·59	40·91
19	38·90	316·72	19·26	...	2·41	109·33	40·79
21	38·99	317·96	18·86	...	1·94	109·05	40·66
23	39·06	319·20	18·45	...	1·47	108·76	40·53
25	39·11	320·44	18·02	37·35	0·99	108·46	40·38
27	39·14	321·69	17·58	...	0·51	108·15	40·24
29	39·15	322·94	17·13	...	+0·03	107·83	40·09
31	39·13	324·19	16·67	...	−0·46	107·49	39·93
Sept. 2	39·10	325·45	16·20	36·43	0·94	107·14	39·77
4	39·04	326·71	15·72	...	1·42	106·79	39·61
6	38·96	327·97	15·22	...	1·90	106·42	39·44
8	38·86	329·24	14·71	..	2·38	106·04	39·27
10	38·73	330·50	14·20	35·53	2·86	105·65	39·09
12	38·58	331·77	13·68	...	3·35	105·24	38·91
14	38·41	333·04	13·15	..	3·85	104·82	38·73
16	38·21	334·30	12·61	...	4·35	104·39	38·54
18	37·98	335·57	12·05	34·68	4·84	103·95	38·35
20	37·73	336·84	11·49	...	5·33	103·49	38·15
22	37·46	338·11	10·92	...	5·82	103·02	37·95
24	37·16	339·39	10·34	...	6·31	102·55	37·75
26	36·84	340·66	9·76	33·88	6·80	102·07	37·54
28	36·50	341·94	9·17	...	7·29	101·57	37·33
30	36·13	343·22	8·57	...	7·78	101·05	37·12
Oct. 2	35·74	344·50	+7·96	...	−8·26	100·52	36·90

A slight alteration has been made in the assumed position of *Mars*' north pole, the value being R.A. 317°·27, N.P.D. 37°·36 at the commencement of 1903.

These are deduced from the revised values recently published

Greenwich Noon. 1903.	☉	Light Time.	Appar. Diam.	Defect of Illumination.	Central Meridian.	Passage of Zero Meridian.	
	°	m	″	″	°	h m	h m
July 28	...	10·728	7·21	0·91	220·86	9 31·99	10 11·91
30	...	10·834	7·14	0·90	201·44	10 51·84	11 31·77
Aug. 1	164·38	10·939	7·07	0·89	182·01	12 11·71	12 51·66
3	...	11·043	7·00	0·88	162·58	13 31·61	14 11·57
5	...	11·146	6·93	0·87	143·14	14 51·53	15 31·50
7	...	11·248	6·87	0·85	123·69	16 11·48	16 51·46
9	168·71	11·349	6·81	0·84	104·24	17 31·44	18 11·44
11	...	11·450	6·75	0·83	84·78	18 51·45	19 31·45
13	...	11·550	6·70	0·82	65·32	20 11·46	20 51·48
15	...	11·649	6·64	0·81	45·85	21 31·51	22 11·54
17	173·11	11·747	6·58	0·80	26·38	22 51·58	23 31·62
19	...	11·845	6·53	0·79	6·90	...	0 11·67
21	...	11·942	6·47	0·78	347·42	0 51·72	1 31·76
23	...	12·038	6·42	0·77	327·94	2 11·80	2 51·84
25	177·57	12·132	6·37	0·76	308·46	3 31 89	4 11·94
27	...	12·226	6·32	0·75	288·98	4 51·99	5 32·05
29	...	12·320	6·27	0·73	269·49	6 12·11	6 52·18
31	..	12·413	6·23	0·72	250·00	7 32·25	8 12·33
Sept. 2	182·09	12·505	6·18	0 71	230·50	8 52·41	9 32·49
4	...	12·596	6·14	0·70	211·00	10 12·58	10 52·67
6	...	12·685	6·10	0·69	191·50	11 32·76	12 12·8
8	...	12·774	6·05	0·68	172·00	12 52 93	13 33·02
10	186·67	12·863	6·01	0·67	152·50	14 13·11	14 53·19
12	...	12·951	5·97	0 66	133·00	15 33·28	16 13·36
14	...	13·038	5·93	0·65	113·50	16 53·45	17 33·55
16	...	13·124	5·89	0·64	94·00	18 13·65	18 53·75
18	191·31	13·210	5·85	0·63	74·49	19 33·85	20 13·95
20	...	13·295	5·81	0·62	54·98	20 54·06	21 34·16
22	...	13·379	5·77	0·61	35·47	22 14·27	22 54·38
24	...	13·463	5·74	0·60	15·96	23 34·49	...
26	196·01	13·546	5·70	0·59	356·45	0 14·60	0 54·72
28	...	13·628	5·67	0·58	336·93	1 34·85	2 14·98
30	...	13·709	5·64	0·57	317·41	2 55·11	3 35·23
Oct. 2	...	13·790	5·61	0·56	297·89	4 15·36	

by Dr. Hermann Struve in the *Mémoires de l'Académie Imp. des Sciences de St-Pétersbourg*, 8ème série (*Math. Phys.*), vol. viii. No. 3.

The difference from the previous values is only nominal—

being +0°·08 in R.A., −0°·05 in N.P.D. Struve's results include a correction for the precessional movement of *Mars'* equator, the annual recession of the point O on its orbit being 7″·07. I did not, however, note this point in time to introduce the correction in the present ephemeris, but hope to do so in future years. The effect on L−O is only about 0°·04, which is practically negligible.

P denotes the position angle of the axis of *Mars* ; L−O+180° the right ascension of the Earth referred to the plane of *Mars'* equator, and reckoned from O, the point of the vernal equinox of *Mars'* northern hemisphere ; Λ−O+180° the corresponding quantity for the Sun ; B *B* the declinations of the Earth and Sun, reckoned from the plane of *Mars'* equator ; Q the position angle of the greatest defect of illumination ; *q* the amount of the same ; E the areocentric angle between the Earth and Sun.

Thus Λ−L is the angle between the meridians of *Mars* which are central to the Earth and to the Sun ; the point where an image of the Sun should be looked for is distant ½(Λ−L) in longitude from the centre of the disc, on the side towards the fully illuminated limb, and is in areocentric latitude ½(B+*B*).

⊙ is the areocentric longitude of the Sun referred to the plane of *Mars'* orbit, and reckoned from O (defined above). This column gives at once the season on *Mars* ; ⊙ = 0° corresponds to March 20 on the Earth, ⊙ = 30° to April 20, and so on.

In accordance with more than one suggestion sent to me, I have altered the value of the diameter of the planet at distance unity from 9″·60 to 9″·30. This is the absolute diameter deduced by Dr. See from a discussion of all the available material. It requires to be increased by the irradiation correction, but as that varies with the size and quality of the telescope, it is better to leave it to the observers to apply the correction. The value used in the *Nautical Almanac* is 9″·36.

The zero meridian and period of rotation have been carried on unchanged from Mr. Marth's last ephemeris, the assumed sidereal rotation in 24^h of mean time being 350°·89202 ; the equivalent period of sidereal rotation is 24^h 37^m 22^s·654 of mean time.

In response to my request for observations of transits of spots across the central meridian, Mr. Lowell has sent me the following observations of the transit of *Fastigium Aryn* :—

Observed G.M.T. of Transit.	Earlier than Ephemeris.	Weight.
1901. d h m	m	
May 4 14 30	8	5
8 17 3	10	2
June 9 13 15	16	2
10 14 3	8	2
July 18 14 35	15	2

From which he deduces that the ephemeris' time was too late by 10^m·5.

I quote his own words as regards the method of observation :—

"These transits were got by setting the micrometer wire parallel to the direction of the axis as given in the ephemeris, and then noting the moment at which the snow-cap and the marking were equidistant from it.

"In order to determine whether the snow-cap itself were eccentrically placed with regard to the pole, I measured its position angle at various longitudes, the preliminary result of which shows its centre to be very close indeed to the pole—within less than half a degree distant. The result gives 0°·32 for its deviation in the direction of the meridian of 90°–270°, so that even this amount would delay, not hasten, the transit of the zero meridian. Consequently the position of the snow-cap will not explain the action, which would seem to be due to error in the epoch or the rotation period, or both."

With regard to this discordance I would point out that Mr. Marth in his last ephemeris altered his zero meridian to agree with Mr. Lowell's observations of 1894, so that we have only the effect of seven years' rotation to consider.

Now the adopted period can scarcely be in error by more than $0^{s}\cdot07$, or twenty-five seconds per annum ; this would only amount to three minutes in seven years.

From the method of Mr. Lowell's observations any error in the angle P would affect the time of transit ; so that if his discordance of 10^{m} is real, I think that the larger portion of it is probably due to error in the assumed position of *Mars'* axis.

M. Antoniadi has communicated to me some observations of the transit of the preceding edge of *Mare Acidalium* across the central meridian, from which he concludes that the error of my ephemeris was inappreciable. I have therefore not considered the evidence sufficiently strong to make any alteration in my constants ; but those who desire can adapt the ephemeris approximately to Mr. Lowell's observations by adding 2°·5 to the central meridian and subtracting 11^{m} from the transit of zero meridian. I may mention that the second decimal place in this last column has no pretence to accuracy, and is merely inserted to diminish cumulative error in the interpolation.

Benvenue, 55 *Ulundi Road, Blackheath, London, S.E.*:
1902 *June* 3.

Erratum in Annual Report.

On p. 314, vol. lxii. *Monthly Notices*, line 8, *for* Roberts *read* Innes.

Errata in Cape Double Star Results, Monthly Notices, vol. lxii.

Page		*For*	*Read*
476	$12^h\ 10^m$	334°·0	344°·0
	13 53	Remark 4	Remark 64
478	*h* 5069	AC	AB, C
479	Sellors	3°·35	335°
	No. 3	−57°	−58°
481	No. 92	83°	183°
482	1901·07	5–4	6–5
484	19^h No. 18	18	21